PROCEEDINGS

OF THE

Iowa Academy of Sciences

FOR 1895.

VOL. III.

PUBLISHED BY THE STATE.

DES MOINES:
F. R. CONAWAY, STATE PRINTER.
1896.

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LETTER OF TRANSMITTAL.

AGRICULTURAL COLLEGE,
AMES, Iowa, February 15, 1896.

To His Excellency, FRANCIS M. DRAKE, *Governor of Iowa:*

SIR—In accordance with the provisions of chapter 86, laws of the Twenty-fifth General Assembly, I have the honor to transmit herewith the proceedings of the tenth annual session of the Iowa Academy of Sciences.

With great respect, your obedient servant,

HERBERT OSBORN,
Secretary Iowa Academy of Sciences.

OFFICERS OF THE ACADEMY.

1895.

President.—H. W. NORRIS.
First Vice-President.—CHARLES R. KEYES.
Second Vice-President.—T. PROCTOR HALL.
Secretary-Treasurer.—HERBERT OSBORN.
Librarian.—H. FOSTER BAIN.

EXECUTIVE COMMITTEE.

Ex-Officio.—H. W. NORRIS, CHARLES R. KEYES, T. PROCTOR HALL, HERBERT OSBORN.
Elective.—N. E. HANSEN, W. H. NORTON, T. H. MACBRIDE.

1896.

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Elective.—W. S. HENDRIXSON, M. F. AREY, W. H. NORTON.

Constitution of the Iowa Academy of Sciences.

SECTION. 1. This organization shall be known as the Iowa Academy of Sciences.

SEC. 2. The object of the Academy shall be the encouragement of scientific work in the state of Iowa.

SEC. 3. The membership of the Academy shall consist of (1), fellows who shall be elected from residents of the state of Iowa actively engaged in scientific work, of (2) associate members of the state of Iowa interested in the progress of science but not direct contributors to original research, and (3) corresponding fellows, to be elected by vote from original workers in science in other states; also, any fellow removing to another state from this may be classed as a corresponding fellow. Nomination by the council and assent of three-fourths of the fellows present at any annual meeting shall be necessary to election.

SEC. 4. An entrance fee of $3 shall be required of each fellow, and an annual fee of $1, due at each annual meeting after his election. Fellows in arrears for two years, and failing to respond to notification from the secretary-treasurer, shall be dropped from the academy roll.

SEC. 5. (*a*) The officers of the academy shall be a president, two vice-presidents and a secretary-treasurer, to be elected at the annual meeting. Their duties shall be such as ordinarily devolve upon these officers. (*b*) The charter members of the academy shall constitute the council, together with such other fellows as may be elected at an annual meeting of the council by it as members thereof, *provided*, that at any such election two or more negative votes shall constitute a rejection of the candidate. (*c*) The council shall have power to nominate fellows to elect members of the council, fix time and place of meetings, to select papers for publication in the proceedings, and have control of all meetings not provided for in general session. It may, by vote, delegate any or all these powers, except the election of members of the council, to an executive committee, consisting of the officers and of three other fellows, to be elected by the council.

SEC. 6. The academy shall hold an annual meeting in Des Moines during the week that the State Teachers' association is in session. Other meetings may be called by the council at times and places deemed advisable.

SEC. 7. All papers presented shall be the result of original investigation, but the council may arrange for public lectures or addresses on scientific subjects.

SEC. 8. The secretary-treasurer shall each year publish the proceedings of the academy in pamphlet (octavo) form, giving author's abstract of papers, and, if published elsewhere, a reference to the place and date of publication; also the full text of such papers as may be designated by the council. If published elsewhere the author shall, if practicable, publish in octavo form and deposit separates with the secretary-treasurer, to be permanently preserved for the academy.

SEC. 9. This constitution may be amended at any annual meeting by assent of a majority of the fellows voting, and a majority of the council; *provided,* notice of proposed amendment has been sent to all fellows at least one month previous to the meeting, and provided that absent fellows may deposit their votes, sealed, with the secretary-treasurer.

ARTICLES OF INCORPORATION OF THE IOWA ACADEMY OF SCIENCES.

ARTICLE I.

We, the undersigned, hereby associate ourselves with the intention to constitute a corporation to be known as the Iowa Academy of Sciences, the purpose of which is to hold periodical meetings for the presentation and discussion of scientific papers, to publish proceedings, to collect such literature, specimens, records and other property as may serve to advance the interests of the organization, and to transact all such business as may be necessary in the accomplishment of these objects.

ARTICLE II.

The membership of the corporation shall consist of the incorporators, and such other residents of the state of Iowa as may be duly elected fellows of the Academy.

ARTICLE III.

The duly elected officers of the Academy shall be the officers of the corporation.

ARTICLE IV.

The principal place of business of the Academy shall be the city of Des Moines, in the state of Iowa.

The capital stock of the corporation is none.

The par value of its shares is none.

The number of its shares is none.

ARTICLE V.

The Academy shall hold an annual meeting in the last week of December, of each year, or upon call of the executive committee, and such other meetings as may be arranged for.

ARTICLE VI.

This corporation shall have the right to acquire property, real and personal, by purchase, gift or exchange, and such property shall be held subject to the action of the majority of its fellows, or the council, the executive committee, or such parties as it may by vote direct to transact such business in accordance with the constitution.

All deeds, leases, contracts, conveyances and agreements, and all releases of mortgages, satisfactions of judgment, and other obligations, shall be signed by the president or vice-president and the secretary, and the signature of these officers shall be conclusive evidence that the execution of the instrument was by authority of the corporation.

ARTICLE VII.

The private property of the members of this corporation shall not be liable for any of its debts or obligations.

ARTICLE VIII.

By-laws, rules and regulations, not inconsistent with these articles, may be enacted by the Academy.

ARTICLE IX.

These articles may be amended at any meeting of the Academy called for the purpose by assenting vote of two-thirds of the members present.

MEMBERSHIP OF THE ACADEMY.

FELLOWS.

ALMY, F. F.---Iowa College, Grinnell
ANDREWS. L. W.---State University, Iowa City
AREY, M. F.---State Normal School, Cedar Falls
BAIN, H. F.---Geological Survey, Des Moines
BARRIS, W. H.---Griswold College, Davenport
BATES, C. O.---Coe College, Cedar Rapids
BEACH, ALICE M.---Agricultural College, Ames
BENNETT, A. A.---Agricultural College, Ames
BEYER, S. W.---Agricultural College, Ames
BISSELL, G. W.---Agricultural College, Ames
CALVIN, S.---State University, Iowa City
CHAPPEL, GEORGE M.---Signal Service, Des Moines
COMBS, ROBERT.---
CONRAD, A. H.---Parsons College, Fairfield
CRATTY, R. I.---Armstrong
CURTISS, C. F.---Agricultural College, Ames
DAVIS, FLOYD.---Des Moines
DREW, GILMAN.---Newton
ENDE, C. L.---Burlington
FINK, B.---Upper Iowa University, Fayette
FITZPATRICK, T. J.---Lamoni
FRANKLIN, W. S.---Agricultural College, Ames
FULTZ, F. M.---Burlington
GOSSARD, H. A.---Ames
HALL, T. P.---Tabor College, Tabor
HANSEN, N. E.---Brookings, South Dakota
HAZEN, E. H.---Des Moines
HENDRIXSON, W. S.---Iowa College, Grinnell
HEILEMAN, W. H.---Ames
HOLWAY, E. W. D.---Decorah
HOUSER, G. L.---State University, Iowa City
JACKSON, J. A.---Des Moines
KELLY, H. V.---Mount Vernon
LEONARD, A. G.---Western College, Toledo
LEVERETT, FRANK.---Denmark
MALLY, C. W.---Agricultural College, Ames
MARSTON, A.---Agricultural College, Ames

MACBRIDE, T. H. ..... State University, Iowa City
NILES, W. B. ..... Agricultural College, Ames
NORRIS, H. W. ..... Iowa College, Grinnell
NORTON, W. H. ..... Cornell College, Mount Vernon
NUTTING, C. C. ..... State University, Iowa City
OSBORN, HERBERT ..... Agricultural College, Ames
PAGE, A. C. ..... State Normal School, Cedar Falls
PAMMEL, L. H. ..... Agricultural College, Ames
REPPERT, F. ..... Muscatine
RICKER, MAURICE ..... Marshalltown
ROSS, L. S. ..... Drake University Des Moines
SAGE, J. R. ..... State Weather and Crop Service, Des Moines
SCHAEFFER, C. A. ..... State University, Iowa City
SCHLABACH, CARL ..... High School, Clinton
SHIMEK, B. ..... State University, Iowa City
STANTON, E. W. ..... Agricultural College, Ames
STOOKEY, STEPHEN W. ..... Coe College, Cedar Rapids
TILTON, J. L. ..... Simpson College, Indianola
VEBLEN, A. A. ..... State University, Iowa City
WACHSMUTH, CHARLES* ..... Burlington
WALKER, PERCY H. ..... State University, Iowa City
WEEMS, J. B. ..... Agricultural College, Ames
WINDLE, WILLIAM S. ..... Penn College, Oskaloosa
WITTER, F. M. ..... Muscatine
YOUTZ, L. A. ..... Simpson College, Indianola

ASSOCIATE MEMBERS.

BALL, E. D. ..... Little Rock
BARTSCH, PAUL ..... Burlington
BEARDSHEAR, W. M. ..... Agricultural College, Ames
BLAKESLEE ..... Des Moines
BROWN, EUGENE ..... Mason City
CARTER, CHARLES ..... Fairfield
CARVER, G. W. ..... Ames
GIFFORD, E. H. ..... Oskaloosa
MILLER, G. P. ..... Des Moines
MILLS, J. S. ..... Eugene, Oregon
OSBORN, B. F. ..... Rippey
OWENS, ELIZA ..... Ames
PAMMEL, EMMA ..... Ames
REED, C. D. ..... Ames
ROLFS, J. A. ..... Le Claire
SIRRINE, EMMA ..... Ames
WEAVER, C. B. ..... Ames

CORRESPONDING MEMBERS.

ARTHUR, J. C. ..... Lafayette, Indiana
BARBOUR, E. H. ..... State University, Lincoln, Nebraska
BEACH, S. A. ..... Geneva New York
BESSEY, C. E. ..... State University, Lincoln, Nebraska
BRUNER, H. L. ..... Irvington, Indiana

* Deceased.

CALL, R. E.---Louisville, Kentucky
COLTON, G. H.---Virginia City, Montana
CROZIER, A. A.---Ann Arbor, Michigan
GILLETTE, C. P.---Agricultural College, Ft. Collins, Colorado
HALSTED, B. D.---New Brunswick, New Jersey
HAWORTH, ERASMUS.---State University, Lawrence, Kansas
HITCHCOCK, A. S.---Agricultural College, Manhattan, Kansas
JAMESON, C. D.---
KEYES, C. R.---State Geologist, Jefferson City, Missouri
LONSDALE, E. H.---Missouri Geological Survey, Jefferson City, Missouri
MALLY, F. W.---Hulen, Texas
MCGEE, W. J.---Bureau Ethnology, Washington, D. C.
MEEK, S. E.---State University, Fayetteville, Arkansas
NEWTON, GEO.---Grand Island, Nebraska
PARKER, H. W.---New York City, New York
PATRICK, G. E.---Hopedale, Massachusetts
ROLFS, P. H.---Lake City, Florida
SIRRINE, F. ATWOOD.---Jamaica, New York
SPENCER, A. C.---Johns Hopkins University, Baltimore, Maryland
STEWART, F. C.---Jamaica, New York
TODD, J. E.---State University, Vermillion, South Dakota
WINSLOW, ARTHUR.---St. Louis, Missouri

PROCEEDINGS OF THE TENTH ANNUAL SESSION

OF THE

IOWA ACADEMY OF SCIENCES.

The tenth annual meeting of the Iowa Academy of Sciences was held in the horticultural rooms at the capitol building in Des Moines, January 1, 2 and 3, 1896. During the business sessions the following matters of general interest were acted upon:

REPORT OF THE SECRETARY-TREASURER.

GENTLEMEN—It is a gratification at this our decennial meeting to report a flourishing condition of the academy. Comparison with our modest beginning, and with our struggles in earlier years to secure a solid foundation and to provide for the publication of results, warrants us in a feeling of satisfaction and of encouragement for renewed effort for the future.

Our membership, which now numbers over 100, includes in its list sixty-three fellows, fifteen associates and twenty-three corresponding members. It represents nearly all the active scientific workers of the state, and also many whose interest and cordial support of such work is of great value. Four of the fellows have removed from the state, and, according to our custom, may be transferred to the list of corresponding members. Four others have, at their own request, or on account of arrearages in dues, been dropped from the academy roll.

Accounts and vouchers submitted herewith show receipts amounting to $153.21 and disbursements of $97.22, leaving a balance charged to the treasurer of $55.99.

SUMMARY OF RECEIPTS AND EXPENDITURES.

Receipts.

Balance from last year	$ 63.16
Ten membership fees at $3	30.00
Annual dues from members	58.00
Proceedings sold	2.05
Total	$ 153.21

Disbursements.

Expenses of ninth annual meeting	$ 6.43
Stationery and stamps, collecting dues	3.41
Printing programs, circulars, etc.	16.25
Author's reprints Vol. II	50.00
Express and postage on proceedings	19.25
Clerk hire, exchange and miscellaneous expenses	1.88
Balance	55.99
Total	$ 153.21

Respectfully submitted.

HERBERT OSBORN.

The committee appointed to examine the accounts of the secretary-treasurer reported as follows:

The committee finds the accounts of the secretary to be correct.

Signed { C. C. NUTTING, C. O. BATES, A. C. PAGE.

REPORT OF THE LIBRARIAN.

DES MOINES, IOWA, December 31, 1895.

GENTLEMEN—I have the honor to submit the following report of my work as librarian of the academy for the year past. The academy is now receiving regularly forty-three serial publications, including the reports of the most important American and some of the foreign societies. In addition, the reports of a considerable number of state and government bureaus are received. The papers are catalogued and placed in the alcove assigned to the academy by the state librarian. Within the past year exchanges have been effected whereby all, or a considerable number, of the back numbers of the following series have been placed upon our shelves:

Transactions Connecticut Academy of Science.

Bulletin New Brunswick Natural History Association.

Proceedings Colorado Scientific Society.

Transactions St. Louis Academy of Science.

Tufts College Studies.

Proceedings Natural Science Association, Staten Island.

Colorado College Studies.

In two other cases exchanges were effected by the combined efforts of the Academy of Sciences and the Geological survey. In these cases it was

thought better to place the books received in the regular collections of the state library. It is proposed to continue the exchange of back sets wherever it can be done to advantage; and for this purpose, as well as to provide for exchanges already made, it is recommended that the academy purchase at least fifteen copies of part one of the proceedings.

Several copies of the back numbers of the academy have been sold and the money forwarded to the treasurer. It is recommended that some more systematic rules regarding the distribution and sale of the proceedings be adopted. Respectfully,

H. FOSTER BAIN,
Librarian.

Professor Hendrixson, for the library committee, made a statement of the work of the committee with reference to scientific books for the state library and the valuable additions that had been made as a result.

The following motion was adopted that a vote of thanks be tendered the librarian and board of trustees of the state library for their courtesies in hearing the requests of the academy and the purchases of scientific works.

A motion that a committee of three be appointed by the chair to petition the legislature regarding the preservation of forest and lake areas of Iowa and to present a memorial to congress through Senator Gear, regarding forest preservation. The committee appointed consists of Professors Macbride, Pammel and Fink. The following was adopted:

DES MOINES, Iowa, January 2, 1896.

The Iowa Academy of Sciences, in regular session assembled, begs leave to call the attention of the Twenty-sixth General Assembly of the State of Iowa to the preservation and protection of our lakes in order to maintain some of the original conditions of the state. They should be made pleasure resorts where our citizens may spend a few days for recreation, and where possible the borders of the lakes should be planted with forest trees. These lakes contain large numbers of fish which alone would pay for their maintenance. They are frequented by many birds which, without them, will be driven from our state.

Your honorable body can leave no richer legacy to future generations than the lakes that dot the northern part of our state surrounded with timber. We earnestly hope the Twenty-sixth General Assembly will pass some measure to preserve them.

(Signed) T. H. MACBRIDE.
L. H. PAMMEL.
B. FINK.

DES MOINES, Iowa, January 2, 1896.

The Iowa Academy of Sciences, in regular session assembled, begs leave to call the attention of the United States congress to the absolute necessity of further legislation looking to the preservation and rational use of the remaining forest resources of our country. The academy petitions for

larger and better guarded reservations, for the enactment of the McRae bill, H. R. 119, or of some similar measure which will yet more stringently guard our forests.

(Signed) T. H. MACBRIDE.
L. H. PAMMEL.
B. FINK.

The following resolution was adopted:

Resolved, By the Iowa Academy of Sciences, that we view with pleasure the efforts toward providing a state building for the preservation of material of historical and scientific value and would heartily endorse the movement for a "memorial, historical and art building."

The following resolutions in regard to papers were adopted:

That hereafter no papers will be published in the proceedings of this academy which are not placed in the hands of the secretary in full, or in a written abstract, before the adjournment of the annual meeting.

That no paper shall be placed upon the printed program of the academy unless the title, when handed to the secretary, be accompanied by a brief abstract and that these abstracts be printed with the program.

The thanks of the academy to the State Horticultural society for the use of their room were by motion tendered.

In the sessions for the reading and discussion of papers the academy listened to the annual address of the president and papers giving results of investigations.

These papers read in full or by title were referred by the council to the secretary for publication and follow herewith:

ANNUAL ADDRESS OF THE PRESIDENT.

NEEDED CHANGES IN SCIENTIFIC METHODS.*

BY H. W. NORRIS.

We live in a period that sees wonderful attainments in science and art, so that in theory and practice many think the *summum bonum* has been reached. It is pre-eminently the age of science and the application of scientific methods to all phases of human activity. The forces of nature have been made subject to the will of man. The relations of man to his surroundings have been carefully considered. The province of human intellect has been made the ground of scientific investigations. We now see scientific methods foremost and uppermost, and all human thought is more or less permeated and even molded by the new ways of looking at the facts of our experience and reason. But with all our enlightenment no other age has equaled ours in the prevalence of unblushing fraud and boasting duplicity.

For every skilled specialist in surgery we have a dozen quacks, whose outrageous pretensions are only equaled by the astonishingly large patronage of the over-credulous. The reputable physician struggles along in his attempts to right the wrongs of the human body according to the best approved methods, and too frequently receives as his reward only nonbankable promises, while Dr. Humbug puts up at the best hotels, advertises to cure all the ills human flesh is heir to, and reaps a harvest of shekels. The name of Dr. X's sarsaparilla is emblazoned along every thoroughfare in the country, and the

* When this address was nearly completed a copy of a recent lecture by President J. M. Coulter, of Lake Forest University, was received, in which were expressed many ideas quite similar to some contained in this paper. Wherein the writer has intentionally borrowed from President Coulter, due credit has been given.

The Botanical Outlook. An address delivered before the Botanical Seminary of the University of Nebraska, May 27, 1895.

merits of the Whoop-up Indian Bitters have even been dramatized for the stage. But the "regular" physician is held responsible for the final taking off of the poor dupes who have resorted to all the patent medicines before consulting the proper authorities. The discoveries of Edison and other investigators of nature's forces are quietly revolutionizing our industrial methods, and we think little of it. But the praises of electric belts, electric bitters and magnetic oils are sounded in every hamlet where the public press finds expression. We have seen in this generation the revival of an old imposture, that travesty on religion and science, the so-called Christian science. Occasionally a new messiah makes his appearance, drawing after him such throngs as to make the possibility of another Joseph Smith not an incredible idea. A visit to one of our interstate or international exhibitions fills us with wonder amounting almost to awe at the marvelous products of genius, a wonder exceeded only by that aroused by a perusal of the advertising columns of our daily papers. That advertising pays cannot be disputed, but the fact that it does pay is often a serious reflection upon the methods of our mental training. Fence corners full of abandoned machinery show, among other things, an unfortunate ignorance of physical laws, and a too-ready acceptance of golden promises. In spite of our bureaus of animal industry, the stock raiser still resorts to patent condition powders and hog cholera cures instead of managing his establishment on a sanitary basis. We are too much under the impression that everything—life, health and happiness, can be purchased with the almighty dollar. So we throw discretion to the wind and leave the results to the Lord and the doctors.

To-day, as it has always been, empiricism is a great hindrance to progress. A specific remedy for a specific evil, a lucky discovery of certain correlated phenomena, a haphazard experimenting with fortunate results, have been all too frequently characteristic of scientific achievements. Great as are the victories science has won in the domains of medicine and the applied arts, they have not been presented to the great public as having a rational basis. In fact the leaders in science see only too dimly the underlying meaning. To many the sole purpose of research is to turn up to view new facts. Facts are presented as interesting, or as having a practical bearing, or as having no bearing at all. The prosaic, dull drudgery of tracing relationship is omitted. Yet nothing exists out of relationship.

In the inductive sciences that deal with facts of most obvious bearings we are magnifying the importance of isolated details and largely ignoring the idea of relationship. As long as people fail to understand that nothing is superior to law, so long may we expect the search for perpetual motion, the elixir of life and the fabled pot of gold. Metaphysicians tell us that the idea of cause is intuitive, yet vast numbers of people act as though cause and effect had no relations whatever in some realms of human experience. The extraordinary success attained by many investigators and inventors has produced a widespread notion that these successful ones are creators rather than discoverers, and that their genius (so-called) transcends common laws. The spirit of speculation so rife in society at present seems to subsist largely on the idea that the common laws of experience are often inoperative. Can we wonder at the enormous sales of patent nostrums as long as there is a widespread opinion that medical science has no rational basis? Can we wonder at the successful impositions of faith-healers and medicine-men when each holder of a physician's diploma is considered a law unto himself, entitled to experiment at his own sweet will on suffering humanity? Is it strange that people fail to be guided by reason when the materials of experience are like so much wind-blown chaff? Says the worldly-wise man of to-day: "My son, be a freak, an honest freak if convenient, but by all means be a freak, for in freak-ism is success."

I therefore make no apology for presuming to make a plea for scientific thought. We may indeed be proud of our achievements in science. In this, the latter part of the nineteenth century, the age of Edison, Pasteur and a host of other investigators, we need make no defense of the position science occupies in human thought and action. The air ship, the electric engine, the dynamite gun, are but faint indications of what is yet to be accomplished. The triumphs of surgical skill are just begun. We see the forces of nature arrayed against each other to give a purer atmosphere, a richer soil, a freer life to mankind. Material considerations outweigh all others in the arena of public opinion. Some say the world has gone mad with science. Scientific studies have crowded themselves into the public schools, colleges and universities in spite of the opposition of the classics. The children lisp in scientific phrases, and the old men sigh for the good old times when ignorance was bliss.

I am neither a prophet nor the son of a prophet, nor am I related by blood or marriage to any prophet or son of a prophet. This age may be as badly in need of prophets as any other age, but what it needs most of all is common sense methods of dealing with the problems that confront it. It seems to me we may profitably spend a little time in the consideration of some of the bearings of scientific methods on current thought and action.

What is the *scientific spirit?* Some would say it is the spirit of the age. But it may well be doubted whether there is such a thing as a spirit of the age. With people and their wants so diverse, the general instability of changing institutions make a universal animating spirit well nigh impossible. But the scientific spirit is something definite and characteristic. We may notice some of the things it is not. It is not the mere seeking for truth, for many who seek the truth are content with half truths. It is not enthusiasm, for the enthusiast too often stands in his own light. It is not the mere collecting of data, for facts and the records of facts in themselves are well nigh worthless. The scientific spirit seeks to demonstrate no proposition; it is not partisan. In short, the man imbued with the scientific spirit seeks the whole truth in all its relations, and accepts its teachings regardless of consequences.

We need to scrutinize very carefully a large amount of the so-called science and scientific methods of to day. The word scientist, has become a sort of abrakadabra, by means of which men hope to conjure up the objects of their hopes and desires. Science is too often interpreted as the triumph of shrewdness over simplicity, the hoodwinking of the ignorant and innocent by the ingenious sharper, or the successful defeat of an opponent through chicanery. So far is this carried sometimes that we are ready to paraphrase that famous expression of Madame Roland and exclaim, "O, science what crimes have been committed in thy name." Any addition to our knowledge that does not affect and improve all classes only lowers relatively the under strata of society; any advance in science which does not adapt itself to the masses only renders them more helpless in the hands of the unprincipled but more intelligent. Science and scientific methods are not for the few, but for the many. We must not assume that scientific methods have no place in common affairs. The scientific spirit is not a new but an old factor in human progress. But we are too much inclined to relegate science and scientific procedures to the specialist, the *scientist*, and as the

specialist and the quack are not distinguishable by the masses the results are often lamentable.

It is said that the cranks and irrational enthusiasts initiate all reform, not the sober, scientific minds; that the scientific mind is conservative and never leads a reform. If this were true, nevertheless it is always the sober, common-sense ideas that really accomplish the final good. Reformers are too often impracticable men. It requires all the best scientific methods combined with the best judgment to achieve the final results and eradicate the evils that follow in the wake of every reformer. We need not so much reformers, for there are plenty of them, but rather the application of scientific methods to the solving of human problems.

The charge is often made that the theoretical sciences are not practical; that they have no direct bearing on the pursuit of health, wealth, and happiness; that they yield no results of value adequate to the time and labor spent on them. Not long ago a bright young scientist lamented to me the fact that his chosen line of work, systematic botany, was so useless, and that biologists in general contributed nothing to the welfare of the human race. It is said that Louis Agassiz made the profession of naturalist respectable in America. Before his time it had been barely tolerated. While scientists of to-day are considered equally worthy with other citizens, yet if their labors do not directly materialize in glittering gold they are everywhere confronted with the question, "Of what good is it?" And, owing to the peculiarities of the questioner, very frequently no satisfactory answer can be given. But an answer is needed.

The teaching of that only which is directly practical tends to swamp all progressive ideas. To restrict our energies to the already known is to degenerate. The cry, "Give us practical studies" is a note of warning. It means stagnating tendencies. To concentrate our energies on practical details too often means to ignore broader relations. We see a wonderful development of technical schools and appliances for the study of the applied arts. To many this seems the scientific goal. Many believe that all our energies should be directed to the promoting of the applied sciences, and that the day of theoretical science is past. So we hear demands for manual training departments of our public schools; demands that the literary and general culture of school life shall be minimized for the enlargement of the practical sciences. We see the young being

hurried into the trades and specialists sent out who know nothing but their little tread-mill round of practice. Is it true that botany, zoology, astronomy, and theoretical chemistry and physics have no great value, and that aside from their purely disciplinary effects they might as well be consigned to the rubbish heap? By many the field of the natural sciences is regarded as a playground where the mind may relax itself in intellectual somersaults.

I would not be understood as antagonizing technical schools, or as depreciating the value of a technical education, but I do say that a general demand for the practical shows something wrong in our educational system. Either we are failing to render the general culture effect of our teaching of much value or we are holding out false notions as to the practical value of our studies. I believe the former to be the true cause. We are not seeking to discipline the mind in proper channels so much as to fill up the cup of mental capacity with scholastic hodge-podge. The great fault of science in our educational scheme is not that it is not practical, but that too often it is not much of anything. We are loading our courses of study with a great bulk of interesting things, "such as every one ought to know something about." Look at the program of studies of the average high school: a term each of botany, zoology, geology, astronomy, physiology, physics, chemistry, etc. What knowledge does the student gain of the inductive methods of study? Occasionally a little, usually none. What practical ideas does he acquire? Some, no doubt, yet in the text-books ordinarily used error is about as conspicuous as truth. If we could confine our science teaching in the public schools to a year of physics and an equal amount of some other one science, and concentrate our energies on quality instead of quantity, method instead of matter, the good results would be ten-fold what they are at present. I am confident that in proportion to the time spent upon it our science teaching yields fewer results than any other line of public school work. The same criticism may be applied to many of our higher institutions of learning. It is no wonder the public calls for something practical.

When the inductive sciences were given such a conspicuous position in our educational system as they occupy to-day, it was thought society was in a fair way to free itself from many errors. But we have too often gone merely from an error to a blunder. Our college and university training has too often

concentrated itself on less important details and ignored broader principles. While it can not be said of many of our colleges, as was recently said of a leading American university, that its zoological department had all run to scales and tail feathers, yet it is true that we are burying relationships under a bewildering mass of details. It must be confessed that some of our latest and most improved methods, notably of those biological studies included under the term morphology, have a tendency to increase rather than diminish this evil. There is always the danger of mistaking the means for the end. The fault of science teaching in our public schools lies in the fact that the student gains little or no conception of the bearing of scientific study on his life. The facts of science are presented as so many isolated entities, interesting or uninteresting as the case may be. The high school must not be looked at and judged as a preparatory school for college training, but as a finishing school for a large part of our school population. The studies should be arranged not as leading to a college curriculum, but as preparing pupils for active life, not by loading their brains with facts, but by training their mental activities. In this latter respect high school science makes a lamentable failure.

I make no tirade against public schools. The fault lies largely and chiefly with the schools that prepare our teachers for science teaching, *i. e.*, our colleges and universities. We may say the public schools are behind the times in this respect, and they are merely following the lead of publishers of antiquated text-books. This may be true, but nevertheless the evils of science teaching in our high schools are only miniatures of those that exist so frequently in our colleges.

What do I consider the pre-eminent good to be obtained from the study of the inductive sciences? To enable the mind to detect the living truths; to perceive that every effect may be referred to an appropriate cause; to see that nothing is independent of relationships; to see that human activities are intimately bound up with other activities; and that the individual is but part of a whole. In other words, to adjust the mind to the sum total of its environment. When we can once establish our scientific training on such a basis, empiricism, charlatanism, and all the frauds that prey on human credulity must beat a retreat.

Fellow laborers, we are not doing our duty. We are too often content with quantity instead of quality. We cover too much ground and look for premature results. We fail to keep in mind the great idea, that method is more than matter, that the result we seek is not accumulation but power, not acquisition but capacity, not bulk but strength. And we also forget that every scientist is a teacher, whether officially so or not. I believe that science and scientific study have a direct bearing on human existence. I believe that the sciences are not merely interesting, disciplinary as studies, practical when applied in the industrial arts, but that the more scientific people are the happier they are, not that they are warmer, or less hungry, or more intellectual, but that they are better adapted to their surroundings. In other words life ought to mean more than struggle, acquisition and success, it should mean better relationships. I do not believe that the chief end of scientific training is skill in invention. I do not think the chief business of the scientist is to produce something practical. This age is preeminently practical, and in so far as it is so it depends largely on scientific methods in vogue. But the satisfaction of bodily wants and natural ambitions is not the goal of scientific research. We need not less but more theory with our practice. The man without a theory is as unbalanced as one with nothing but a theory. The aim of scientific research is to find the ideal adjustment of man to his environment, and that relation will never be attained by purely practical means.

We see to-day an immense number of so-called investigators engaged in original research. Probably one-half of these know little or nothing beyond their specialties. Many of them are engaged in matters of little general import, and see only a very circumscribed horizon. Many of them are unable to see the relations of their special studies to anything else. So they drift into empiricism, narrowness, and dogmatic assertions. We are teaching men to specialize before they can generalize, and the results must be unfortunate. A large part of these investigators are entirely out of place. To become a specialist in science one must be more than merely able to manipulate a microscope, or to set up a dynamo, or to mix chemicals without a disastrous explosion. Whatever may be said pro and con regarding the old system of industrial apprenticeship, this is certain, that no one can become a reliable investigator without a long and laborious service of preparation. We are putting

the label, investigator, upon too much crude material. To quote President Coulter: "Teachers assume a serious responsibility in urging born hod carriers to become architects."

I do not wish to be understood as decrying original research or specialization of studies. On the contrary, I believe every earnest thinker needs to concentrate his energies now and then on special investigation, but every act in specialization should rest on a foundation of broad culture. No scientist should be content to pass off the field of activity without leaving the store of human knowledge richer for his having lived. If we consult the life records of those who have done most to put the various branches of science on a broad rational basis, we see that they have been men who have got at the heart of nature through special investigations. Only those who have labored themselves can rightly interpret the labors of others. Knowledge is not the goal. Truth for truth's sake may be good, but not best. Unrelated ideas are as valueless as mummies buried beyond all discovery. We are making an egregious mistake when in our teaching or researches we emphasize a detail here and a detail there and utterly fail to find any relationships. Yet this is just what is done over and over again by our so-called investigators. Year after year they extol their special hobbies and lament that the world calls them visionary.

I believe in the popularization of science. It would be entirely out of place for me to assume that any member of this academy believed in what is known as popular science, which in fact is usually no science at all. I believe that science should be made popular, not by prostituting its aims and methods to the pleasing of public fancy, but by educating the masses in the methods and applications of science. Correct thinking is prerequisite to correct acting. Yet how often do we labor simply to reform the acting! Comparatively speaking, of what lasting good can be the triumphs of science of our day if only the purely practical results impress themselves on the public mind? If our discoveries, little and big, are to be applied as so many patent nostrums how meager the results! If the *rationale* of science is to be restricted to the sphere of the highly educated classes and the wonderful results of research are to be regarded as empirical by the masses, how discouraging the prospect to one who has at heart the welfare of the whole race! Pasteur and others have well nigh succeeded in placing medical science on a rational basis, yet how few comprehend the actual state of

matters! How many physicians themselves look upon their profession as founded on empirical data! The failure of the public to recognize fundamental principles accounts largely for the success of many of the frauds of our day. We look upon professional and technical schools as places where the student gains skill in manipulating and proficiency in experimenting, and too often that is all they are. The scientist is often justly accused of isolating himself and his work from the sphere of human activity, of seeking his little bit of truth merely for the truth's sake, never dreaming that his greater duty is to relate himself and his work to the great body of truth. No one has a natural monopoly on truth any more than on any other reality. I do not believe in a scientific Olympus where above the clouds and turmoil of the common place, far from the maddening crowd, can dwell the votaries of science indifferent to the problems that perplex the masses. If the true aim of scientific study is to find the ideal adjustment of man to his environment our present progress in realizing that aim is altogether too slow and uncertain in comparison with our pretensions. We must make radical changes in the ways we are presenting the facts and methods of science to the public.

The observing minds of to-day cannot fail to see that modern civilization is on the point of some great changes. The first half of the twentieth century will see enacted what would now seem subversive of the present best order of things. The wisdom and folly, success and disaster, attending these changes will depend largely on the scientific or unscientific means employed in attaining desired ends. It is basest folly to attempt to solve society's problems with leaving out of sight fundamental human laws. There is no true science of sociology yet formulated. The dictum of the social reformer is the baldest empiricism. We can never get anywhere by Bellamy colonies and Brook Farm experiments. Why then advocate social schemes to which not even the angels in heaven could conform much less men of flesh and blood? If sociology is ever to be established on a rational basis it must take man as he is, and as he has been, a creature of bone and sinew, ever striving for better conditions and never presenting phenomena that are independent of natural laws. Sociology can be made a science only by laborious patient endeavor. Humanity's problems cannot be solved in a day, nor a year, nor a lifetime. No one man can solve them. The chemist, the biologist, the

physicist, the ethnologist, the mechanic, must assist. What a pathetic spectacle is presented in the charitable and mission work man is doing for his fellow man. It is the old story of eradicating one evil and sowing the seeds of a dozen more. How little of philanthropic work aims at more than alleviating present conditions! Were it not for the fact that in some instances, and they are all too few, the highest of scientific attainments are being directed toward studying and correlating the fundamental laws of society for the purpose of establishing abiding criteria of action I should deem the field of social reform utterly hopeless. We evidently need not so much a change of method here as a change from no method at all to a scientific method.

The scientific world stands committed to the theory of evolution, for by no other can the existing order of things be explained, even though much is as yet unexplained. It is the only thing that can bind our scientific knowledge into a cohering whole. Any ignoring of it plunges into deepest empiricism. The ideas of growth, development, change from simple to complex, and resulting inter-relationships are extremely vague in popular thought. Particular modes of procedure are often mistaken for general principles, this or that theory for a law. One of the greatest obstacles that the theory of evolution, the only real interpreter of facts, has had to contend with has been and is now the widespread belief in infallibility—infallibility of all knowledge. Yet no more important truth needs to be learned than that the wisdom of to-day may become the folly of to-morrow. A change in belief is too often mistaken for an exchange of an old for a new dogma. The fact that scientific theories and knowledge in the year 1896 are not like those in the year 1859 constrains many, particularly those of a theological bias, to deny any truth in either. Nor do many scientists place themselves in any more commendable attitude. Some of our scientists give evidence of as intolerant a dogmatism as ever disgraced ecclesiastical history. The man who assumes infallibility of scientific knowledge, in whole or in part, thereby puts himself beyond the pale of truth seeking.

President Coulter notices among botanists of to-day several bad tendencies. Some of them have so wide an application that I may use them in recapitulating my preceding statements: 1. *The tendency to narrowness.* This is shown in the magnification of details, and minimizing of relationships; in the failure

to recognize the applications of science in whole or in part. 2. *The tendency to certainty*—dogmatism, infallibility. This reaches its culmination in the balancing of a scientific chip on the shoulder. 3. *The tendency to mistake acquisition for the power to do something.* This is profoundly characteristic of science teaching in our educational system. 4. *The tendency to immature research* —dilettantism. To which I would add: 5. The tendency to Phariseeism; the scorning of all not scientists; a holier-than-thou attitude that puts the possessor out of touch with human struggle; the despising of all efforts that are not of a certain superfine order; lack of charity for fellow scientists; criticism of every man's honest endeavor. 6. The tendency to minimize theoretical considerations; the cry for the practical.

It is obvious that these tendencies cannot fail to create a feeling in popular thought of distrust, contempt, and disregard of science and scientific methods. The effect on the scientist is stultifying, narrowing, dogmatizing. The worst result will be that progress in solving humanity's problems will be retarded. Every tendency to restrict the application of scientific methods is detrimental to progress.

I believe that science and the methods of science must take in the future a greater share in shaping the destiny of the race than they have in the past, not so conspicuous perhaps, but none the less real. I believe most profoundly in an earthly order founded on a scientific basis. I see no other hope for society. I am not visionary. Hence I can make no forecast of a rainbow-tinted land of promise, wherein the plutocratic lion deals with the democratic lamb on a strictly scientific basis. Scientific method is not a universal panacea. But the problems that perplex humanity will be settled justly only as they are approached from a rational standpoint,

I am not pessimistic as to the future of science. But the best results will not be achieved unless some of our methods are radically changed. Materialism and philosophic nihilism are no bugbears to me. Though science and scientific methods cannot make a perfect humanity, any attempt to solve the problem by ignoring science is basest folly. I believe the day will come when empiricism and its twin brother dogmatism will yield the field to the scientific spirit. Speed the day!

HOMOLOGIES OF THE CYCLOSTOME EAR.

BY H. W. NORRIS.

The ear of the Cyclostomata has until recently been considered so peculiar as to render it difficult to explain its relations to the typical Vertebrate ear. Then again, the diversity of structure in the auditory organ of the Cyclostomes themselves renders the task of homologizing the various parts somewhat uninviting.

Our exact knowledge of the structure and relations of the ear of the Cyclostomata begins with the researches of Ketel[1], in 1872. His predecessors had assumed that the auditory organ of the Cyclostomata was a thing *sui generis*, hence most of their observations were defective. Ketel was the first to attempt to find a fundamental type of the vertebrate ear. While the results of his studies in that direction did not find ready acceptance, nevertheless, in the light of most recent investigations, we see that his conclusions were essentially correct. In the light of zoölogical knowledge twenty years later, his opinions would have seemed not only reasonable, but they would have been considerably modified from their original form. Johannes Müller[2] in 1836 discovered the semicircular canals in the ear of Petromyzon, and that they were only two in number. Dumeril[3] in 1800 claimed to have found the canals, but his statements are extremely vague. Other observers, Pohl[4], Weber[5], Blainville[6], Rathke[7] and Breschet[8], had denied the existence of the

[1] Ueber das Gehorogan der Cyclostomen.—Hasse *Anat. Studien*, 1872.

[2] Ueber den eigenthumlichen Bau des Gehororgans bei den Cyclostomen. *Fortsetz d Vergl.* Anat. d. *Myxinoiden in Abh d. K. Akad. d Wissen.* Berlin, 1836.

[3] Anatomie des Lamproies *Memoires d anatomie comparee.* Paris, 1800.

[4] Expositis generalis anatomica organi auditus per classes animalium. Vindobonae, 1818.

[5] De aure et auditu hominis et animalium. Leipzig, 1820.

[6] De l'organisation des animaux ou Principes d'anatomie comparee. Paris, 1822.

[7] Bemerkungen uber den inneren Bau der Pricke. Danzig, 1826.

[8] Recherches anatomiques et physiologiques sur l'organe de l'ouie des poissons. *Acad. des Sci Savans Etrangers.* 1838.

canals, or at least any more than as rudiments. It was very early recognized that two distinct forms of ear were to be found in the group of Cyclostomata, the one found in the Myxine and the other in the Lampreys. Müller[9] first gave any adequate description of the ear of Myxine. Previously Anders Retzius[10] had given a very meager description. Ketel attempted to show that the ear of Myxine is genetically related to that of higher vertebrates through the ear of Petromyzon as a connecting link. Unfortunately he failed to recognize the existence of semicircular canals in the ear of Myxine, considering the membranous vestibule as merely a ring. Ibsen[11] had in 1846 recognized a semicircular canal in Myxine and two ampullae.

Ketel considered the Cyclostome ear as in an arrested stage of evolution, and that it really represented an ancestral condition of the Vertebrate ear. He sought for traces of the third or horizontal canal in Petromyzon, and believed he found it in a sense organ connected with the *crista acustica* of the anterior canal. The cochlea he found represented in the "sackartiger Anhang" of the membranous labyrinth. Ketel failed to completely homologize the Cyclostome ear with that of the Vertebrate type, because he did not recognize the existence of semicircular canals in Myxine, and further, because, working from the higher types downward, he had not grasped the idea of the fundamental form of the auditory organ. Gustav Retzius[12] in 1881 recognized the existence of a single semicircular canal in Myxine; but he did not agree with Ketel as to the relationships of the ear of the Cyclostomata. It remained for Ayers[13] in 1892 to establish beyond question the rank of the Cyclostome ear. Starting with the idea that the Vertebrate auditory organ is composed of modified sense-organs of the lateral line system, he shows almost beyond question that the Cyclostome ear is not a degenerate structure, but rather represents an ancestral type. According to this interpretation, we recognize in the Vertebrate ear two originally distinct parts, an anterior utriculus and a posterior sacculus, with which, and forming a part of, are a number of canals. The ear of Myxine

[9] Loc. cit.

[10] Ytterligare Bidrag till anatomien af Myxine glutinosa. *Kongl. Vet.-Akad. Handl.* Stockholm, 1824.

[11] Anatomiske Undersogelser over Orets Labyrinth, afsluttet af Forgattern i 1846.

[12] Das Gehororgan der Wirbelthiere I, Stockholm, 1881.

[13] Vertebrate Cephalogenesis, II. A Contribution to the Morphology of the Vertebrate Ear, with a Reconsideration of its Functions. *Journal of Morphology, Vol. VI, Nos. 1 and 2.* 1892.

is seen to consist of a utriculo-sacculus, imperfectly divided into two parts, into which open two canals, each with an ampulla containing a sense organ. Unlike the condition in the Lampreys, or higher Vertebrates, the two canals unite with each other without an unpaired connection, or commissure, with the vestibule. Hence the failure heretofore to recognize more than one canal. The ear of Petromyzon differs from that of Myxine chiefly in the fact that the two canals are connected with the membranous labyrinth at their point of union by an unpaired commissure. The two semicircular canals of the Cyclostome ear correspond to the anterior and posterior canals of higher Vertebrates.

The anterior is connected with the utriculus, and the posterior with the sacculus, at their ampullar ends. In other vertebrates the connection of the posterior canal with the sacculus is lost at an early stage of development, so that the three canals in the adult are connected only with the utriculus. This, however, is not the ancestral nor the early embryonic condition. Embryology[14] indicates that the vertebrate ear early consists of two parts, an anterior utricular and a posterior saccular region. This is the adult condition in the cyclostomes. Ayers calls particular attention to the fact, which Ketel, Hasse, and Retzius had already noticed, that in Petromyzon there are two distinct endolymphatic ducts, a further striking indication that the vertebrate ear is a two-fold structure in origin. Ayers, however, gave the first explanation of their presence. That the existence of these two ducts is a fundamental characteristic, is indicated by the fact that they are distinct from a very early stage of development.

Unfortunately the material at my disposal does not give a complete series of the development of the ear, but the stages studied by me indicate that Ayers is correct in his interpretation of their presence. Thus we see that recent investigation confirms the opinion of Ketel that the auditory organ of the Cyclostomata is not an aberrant structure. Ayers may be said to be the first and only one who has given a coherent explanation of the structure and origin of the Vertebrate ear.

[14]H. W. Norris. Studies on the ear of Amblystoma. Part I. *Journal of Morphology, 1892.*

ORIGIN AND SIGNIFICANCE OF SEX.

BY C. C. NUTTING.

This paper is not presented as a contribution to our knowledge of the subject of the origin of sex, so much as an attempt to express concisely a theory of sex drawn from various sources, but principally from a work on the "Evolution of Sex" by Geddes & Thomson, a work which seems to me to mark an epoch in the science of philosophical biology.

My excuse for presenting this subject before you to-night lies in the fact that it has been my fortune within the past year to personally investigate the origin of the sex-elements in one group of animals, the hydroids, and to follow in the footsteps of that great master August Weismann, whose studies have given such an impetus to the search for truth in the realm of sex and heredity.

My own studies have resulted in a conviction that there is truth in the theory advanced by Geddes & Thomson, and my effort this evening will be to state this theory, in a slightly modified form, in a series of definite propositions, each one of which I believe to be defensible, if not invulnerable.

First, however, it will be necessary to call to your minds the most important facts concerning reproduction among the one-celled animals, or *Protozoa*.

The simplest form of reproduction is that of the amoeba, in which there is a simple division of the body mass of the parent cell into two portions, each of which becomes an independent organism. This is known as the process of reproduction by fission.

Turning to a somewhat higher group of *Protozoa* we find another step introduced in the reproductive process. If we study the Paramecium, for instance, we will find that it multiplies by fission, as does the amoeba, but that at intervals

another process takes place, two individuals becoming adherent, the cell walls in the region of contact being dissolved as punctured, and an interchange of the protoplasm taking place. After this the individuals separate and the process of fission is renewed, and goes on for many generations. Ultimately, however, the process of conjugation is again resorted to.

In certain of the *Vorticellidæ* the reproductive process is still further complicated by the fact that the fission is not simple but multiple, one of the halves resulting from simple fission again dividing into a number of small ciliated bodies, each of which is capable of uniting with a normal vorticella in the process of conjugation.

In certain Acinetans the multiple fission is internal, the parent cell having its contents broken up into a number of ciliated bodies, which escape through the ectosarc.

We thus see that in going from the lower to the higher Protozoa we find the reproductive process growing more and more complicated. First in the amoeba we find simple fission, then in the Paramecium we find simple fission plus conjugation. In the vorticella we have simple fission plus multiple fission plus conjugation. In the acinetan we find simple fission plus internal multiple fission plus conjugation.

Such, then, are the facts. We now turn to seek an explanation.

Anabolism is the constructive, conservative, potential energy of the cell.

Katabolism is expressed in the destructive expenditure of this energy in active or kinetic processes.

The growth of any normal cell has a necessary limit due to a purely physical cause. The mass increases as the cube of the diameter, while the surface increases only as the square. The surface performs the function of respiration, but it cannot perform this function for an unlimited mass any more than a cubic inch of lung can perform respiration for a full grown man.

As a cell increases in size its mass increases more rapidly than its surface, until a point is reached beyond which it can not grow, because the surface can supply no more oxygen. It is worked to its limit, and can not respond to increased demands. At this stage there are three possibilities:

First.—Death, which would end the question.

Second.—Stationary balance, which is impossible.

Third.—Katabolism, which would cause the cell to disappear, or anabolism would recur at a certain point, and we would thus have an alternation or rhythm of katabolic and anabolic states.

This is logically conceivable, but it would debar the possibility of reproduction, and the individual cell would be theoretically immortal, but as a matter of fact would be destroyed ultimately by accidental means.

If, when the cell had reached the limit of size, it should divide, either accidentally or otherwise, there would result two individuals, both small enough to admit of an expression of anabolism in growth.

There would thus be two organisms to hold the fact of specific existence instead of one.

Therefore, any cell which would divide would have double the chance of perpetuation that a single cell would.

In other words, cells capable of spontaneous or mechanical fission would be selected and preserved by natural selection.

Let 1,000 generations proceed thus by simple division or fission. By this time considerable differences would exhibit themselves in the descendants of our original cell, owing to differences in environment and food supply.

One line of cells would be abundantly fed, would grow *large, inactive, anabolic.* Another line would be insufficiently nourished, and would grow smaller, more active, *katabolic.*

Taking the large anabolic cells, we find:

First.—They tend to become more and more inactive. (Activity may express itself either in motion or cell division.)

Second —The anabolic cells accordingly tend to become quiescent on the one hand, and to cease dividing on the other.

Third.—This tendency would ultimately result in death, if not in some way counteracted.

Taking the smaller katabolic cells, we find:

First.—They tend to decrease in size.

Second.—They tend to become more and more active.

Third.—Their expenditures would eventually bankrupt them, they would be worn out, would die of exhaustion.

Taking the two kinds of cells we find:

First.—One needs something that can express itself in cell division, *Katabolism.*

Second.—The other needs nourishment which would express itself in growth, *Anabolism.*

In other words:

One is full and dying of plethora.

The other is hungry and dying of excessive expenditure of energy.

It would evidently be a good thing for them to pool their issues.

This is effected by the process of conjugation, whereby:

First.—The small, active, katabolic cell imparts its energy (kinetic) to the large passive cell, and that energy expresses itself in *cell division.*

Second.—The large, passive, anabolic cell imparts to the daughter cells its anabolic propensities which express themselves in *growth.*

In other words:

The anabolic cell receives the impetus necessary to cell division or fission, and the katabolic cell receives nourishment and the tendency to grow.

What brings them together?

Hunger, or its equivalent.

Hunger is a fundamental property of all things that need nourishment.

It is therefore a property of katabolic cells. The small, active cells need nourishment. The large, anabolic cells are packed full of nourishment.

Example—Acinetan.

An intensification of this process would be brought about in time by natural selection and would result in *multiple fission*, external and internal, which is the highest expression of sex found among the Protozoa.

SEX IN THE METAZOA.

Hydroid as a Type.—The male cells originate from amoeboid endodermal cells which differentiate along the line of kataboliism. They divide repeatedly and eventually become the smallest and most active cells in the colony. The female cells originate from amoeboid endodermal cells which differentiate along the line of anabolism. They grow excessively and become passive and circular in outline. They eventually become the largest and least active cells in the body.

These two cells unite, or the smaller seeks the larger and is absorbed in it. As a result:

First.—The small, active cell imparts its kinetic energy to the large, passive cell, and that energy expresses itself in cell division.

Second.—The large, passive, anabolic cell imparts to the daughter cells its anabolic propensities, which express themselves in growth.

By the growth and division of cells every organism, from the hydroid to man himself, attains its perfection.

It will be seen from what has been said that there is no fundamental difference between the reproductive processes in the Protozoa and Metazoa. All of the complicated machinery associated with sex in the higher forms are merely accessory to the fundamental fact of the meeting of two cells, an intermingling of protoplasm and a subsequent cell division, all of which phenomena are essentially present in the conjugation and fusion of the *Paramecium* for instance.

As to the *significance of sex*, it is not sufficient to say that it serves to perpetuate the species. It does much more. It serves to *improve* species in that the commingling of the characteristics of two parents furnishes the main potentiality for individual variation among the offspring. Indeed, Weismann stoutly maintains that we have here the only cause for individual variation upon which natural selection can act, and he believes that evolution would be impossible among sexless animals. However this may be, it is clearly true that progress is much more rapid and certain by virtue of the fact that most individuals animals have a *father and a mother.*

It would be impossible in the limits of this paper to discuss the tremendous ethical, social and moral significance of sex. It must suffice to suggest that altruism had its birth in the world when brutes first cared for and protected their helpless young, and that through the social relations of parent and child, husband and wife, all that is purest and best in human affairs found its inception and its impetus.

THE REDUCTION OF SULPHURIC ACID BY COPPER AS A FUNCTION OF THE TEMPERATURE.

LAUNCELOT W. ANDREWS.

The object of the experiments described in this paper was to determine whether the reduction of sulphuric to sulphurous acid by copper takes place at a lower or at a higher temperature than the incipient dissociation of the former compound into water and the acid anhydride.

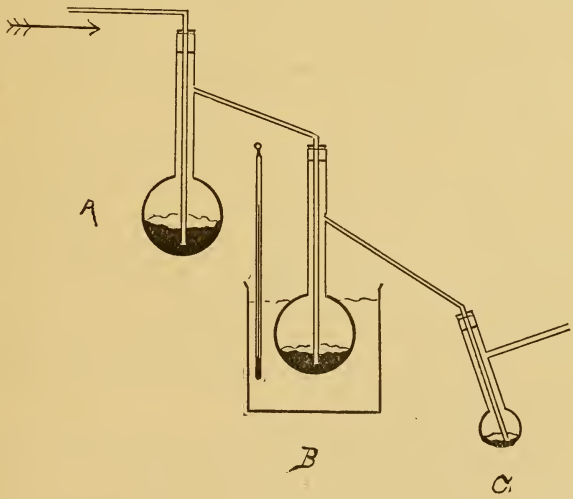

FIGURE 1.

The sulphuric acid employed was the ordinary pure product, containing 98.4 per cent of H_2SO_4. The apparatus illustrated in the figure was used.

The method employed was to heat the copper with the sulphuric acid (in flask B) gradually in a sulphuric acid bath while

passing a dry current of air or of carbonic anhydride through it. The escaping gas was then tested (in flask C) by suitable reagents, to be described, for sulphuric and sulphurous anhydrides respectively. Flask A contained concentrated sulphuric acid of the ordinary temperature (25°C) to dry the gas, which was usually passed at the rate of about eighty bubbles per minute. The importance of securing absence of dust from the acid being recognized, the interior of the whole apparatus was washed with boiling concentrated sulphuric acid and dried in dustless air.

Experiment I.—Flasks A and B were charged with concentrated sulphuric acid and C with a solution of barium chloride. Air was drawn through the whole in a slow current for fifteen minutes. The solution in C remained clear. B was now very slowly heated while the current of air was maintained.

Before the bath reached 70°C there appeared in C a faint turbidity of barium sulphate, which at the temperature named became distinct. At 60°C the solution remained unchanged, even after passing the air for a long time. Hence sulphuric acid of the given concentration begins to give up sulphuric anhydrides, that is, it begins to dissociate at a temperature lying between 60° and 70°C.

Experiment II.—The apparatus charged as before, with the addition of pure bright copper wire in B, and with highly dilute iodide of starch instead of barium chloride in C. After passing air for several hours at the ordinary temperature, much of the copper had gone into solution and anhydrous copper sulphate had begun to crystallize out, but the iodide of starch, made originally very pale blue, retained its color.

This shows that in the presence of air, sulphuric acid is attacked by copper at ordinary temperatures, but without reduction of the acid. The reaction must take place in accordance with the equation:

$$2Cu+O_2\ \ 2H_2SO_4=2Cu\,SO_4+2H_2O.$$

Experiment III.—This was like the last, except that the apparatus was filled with carbonic anhydride, and a current of this gas was substituted for air.

The copper was not attacked, and the starch iodide was not decolorized. The temperature of B was now slowly raised, and when it reached 90° the solution in C was bleached. In a similar experiment a solution of dilute sulphuric acid, colored pale straw with potassium bichromate, was used as an indicator for

sulphurous acid in C. In this case the change of color did not occur until the temperature had risen to 108°, the indicator being, as might be expected, less sensitive than the other.

Experiment IV.—Same as III, except that a reagent for both sulphuric and sulphurous acid was used in C.

This reagent was prepared by slightly acidifying a solution of barium chloride with hydrochloric acid and then adding enough potassium permanganate to render the solution pale rose color.

This indicator is capable of showing the presence of considerably less than $\frac{1}{100}$ m. g. of sulphurous acid.

When the temperature of the bath had reached 70°C the solution in C was distinctly turbid with barium sulphate, but its color was unaltered. At 86° it began rather suddenly to bleach, and at 87° it was colorless. Special care was taken in filling B not to get any sulphuric acid on the neck or sides of the flask. A repetition of this experiment gave identical results, the gas being passed at the rate of two to three bubbles per second.

The conclusions to be drawn from this investigation are:

First.—That the dissociation of sulphuric acid of 98.4 per cent. begins to be appreciable at a temperature somewhat below 70°, which may be estimated at about 67°.

Second.—The reduction of sulphuric acid by copper does not begin below 86°, that is, not until the acid contains free anhydride.

The assertion made by Baskerville,[1] that sulphuric acid is reduced by copper at 0° is, therefore, incorrect. He appears to have based the statement, not on any demonstration of the formation of sulphurous acid, but solely on the formation of copper sulphate, which occurs, as I have shown,[2] in consequence of the presence of air.

A more careful repetition of his experiments under conditions securing entire exclusion of air can but lead him to a different conclusion from that he obtained at first.

The fact adduced by him that under certain conditions cuprous sulphide may be formed by the action of the metal upon sulphuric acid does not allow any conclusions to be drawn respecting the presence of "nascent" hydrogen, since it may be explained perfectly well either by the direct reducing action

[1]Journal of the Am. Chem. Soc., 1895, 908.

[2]Traube has shown the same thing for dilute sulphuric acid. *Ber. 18*, 1888.

of the copper or by Traube's theory which is backed up by almost convincing evidence[3].

Stannous chloride will reduce sulphuric acid with formation of hydrogen sulphide and free sulphur, an analogous reaction in which the assumption of "nascent" hydrogen is inadmissible.

[3]Moritz Traube, *loc. cit.* and *Ber.*, 18, 1877, etc.

CLAYS OF THE INDIANOLA BRICK, TILE AND POTTERY WORKS

L. A. YOUTZ, INDIANOLA.

Analyses of several clays from a brickyard at Indianola have recently been made by me to go into a report of the Geological Survey of Warren county. Though it has been said that a knowledge of the constituents of a clay, determined by a purely chemical analysis, is of very little value to a practical brickmaker, yet in comparing the analyses of these clays and those from other vicinities, it seems that points of great value to the manufacturer are made plain, and points that can be derived from no other source. So I wish to give a few ideas which came to me as I made the comparison, as points, of local interest at least, were, it seems to me, clearly brought out.

In order to get an intelligent idea of the value of this clay for brick and tile it may be helpful to give a short outline of some of the qualities of clay for the various kinds of brick. The quality and character of brick depends, of course, primarily upon the kinds of earth used; the mechanical mixing, drying and burning being important items, however.

The varieties of clay most frequently used for common bricks are three. The so-called blue clays, hydrated aluminum silicates, combined with small quantities of iron, calcium, magnesium and alkalis; sandy clays or loams, and marls which contain a large proportion of lime and magnesium. In addition to these are the clays for special kinds of brick, as fire-brick, pottery, terra cotta, etc. Hydrated silicate of aluminum is infusible even at the most intense furnace heat, but if these be mixed with alkalis, or alkali earths, it becomes fusible, and in

about the proportion of the admixture. So that clays containing more than about 3 per cent of lime can not be made into good brick from this fact, and that the calcium carbonate being reduced to calcium oxide by heat will slack by moisture and the brick then crumble. However, by burning at a higher temperature than is usual the injurious effect of lime can be greatly overcome unless it is in so great quantity as to lower the fusing point too much. The amount of combined water in a clay is a very important item in determining its adaptability for good brick. In a pure hydrated silicate of aluminum so much water will be given off by burning that the brick in going through the sweating process become too soft and run together, or else crack so as to be made much inferior. So all pure clays for brick must be mixed with sand, powdered quartz, powdered brick, gangue, or some such material, in order to alleviate this difficulty. In loams a certain per cent. of lime or similar material needs to be added to act as a flux, as too much sandy material makes the brick brittle. Marls in this country have been, it appears, but little used for brick making, as the lime is supposed to be detrimental. Yet in Europe a very fine malm is made from marls having as high as 40 per cent or more of calcium carbonate. They simply heat the brick probably 200 degrees higher than the ordinary brick. This gives the brick a white color instead of red, the iron and calcium being united with the aluminum as a ferric-aluminum-calcic silicate.

Of the Indianola brick clays, analyses of two samples will be sufficient for our purpose of comparison. The brick are made from a certain small deposit of blue clay, taken probably twenty feet below the surface, mixed with a much larger proportion of a darker colored clay immediately above this blue layer.

The lower strata gave the following analysis from the air dried samples:

SiO_2	66.779
Al_2O_3	19.525
Fe_2O_3	.72
CaO	trace
Loss dried at 100°	8.08
Loss by ignition	5.48
Total	100.584

The sample above this as follows:

SiO_2	67.85
$Al_2O_3+Fe_2O_3$	20 45
Ca O	1.19
Mn O	trace
K_2O	trace
Loss dried at 100°	3.47
Loss by ignition	7.12
Total	100.08

It will be seen that in each there is a large per cent. of silica and alumina. The upper containing more free silica, consequently gave a higher per cent of silica and alumina, but contained a considerably smaller per cent. of hygroscopic moisture, The higher loss by ignition in the upper stratum being due doubtless, to a larger amount of organic matter near the surface. Lime was present in the upper stratum in appreciable quantity, and iron in small quantity in each. A trace of manganese oxide in the upper stratum.

From Crossley's "Table of Analyses of Clays" for common brick we take three average samples, which are as follows:

Common brick clay:

SiO_2	49.44
Al_2O_3	34.26
Fe_2O_3	7.74
Ca O	1.48
Mg O	5.14
Water and loss	1.94
Total	100.00

Sandy clay:

SiO_2	66.68
Al_2O_3	26.08
Fe_2O_3	1.26
Mg O	trace
Ca O	.84
Water and loss	5.14
Total	100.00

Marl.—London "Malms."

$SiO_2+Al_2O_3$	43.00
Fe_2O_3	3.00
Ca O	46.50
Mg O	3.50
Water	4.00
Total	100.00

Comparing the Indianola clay with these, with the first it is at variance especially in silica, alumina, and oxide of iron. With the second it corresponds very well except in Al_2O_3 and in having more water. But we could not call it a sandy clay. The upper layer contains a little sand, but the lower practically none. To the third there is no comparison.

It seems then as these clays represent the three common classes of brick, that this clay at Indianola must represent a kind which though it may make, as it has proven itself to do, good common building brick, yet it may be adapted to other kinds of brick.

The Stourbridge, England, clays, from which the world-famed fire brick are made, yield, by averaging the analyses of four different clays, the following proportion of materials:

No. 1.

SiO_2	64.95
Al_2O_3	22 92
Fe_2O_3	1.90
$CaO+MgO$	.64
K_2O+Na_2O	.37
H_2O loss	9.60
Total	100.38

Woodbridge fire clay bed, New Jersey, also famous for its quality of refractory clays, as follows:

No. 2.

SiO_2 combined	40.50	
SiO_2 free (quartz sand)	6.40	46.90
Al_2O_3	35.90	35.90
TiO_2	1.30	1.30
K_2O+Na_2O	.44	
Fe_2O_3	1.10	1 54
H_2O combined	12.80	
H_2O hygroscopic	1.50	14.30
Total	99.94	99.94

From Trenton, New Jersey:

No. 3.

SiO_2 combined	17.50	
SiO_2 free (quartz sand)	56.80	74.30
Al_2O_3	18.11	18.11
K_2O+Na_2O+CaO	1.07	1.07
$Fe_2O_3+H_2O$	6.99	6.99
Total	100.47	100.47

These three samples of fire brick clays are selected from a list of about 100 analyses of clays taken from various parts of the United States and Europe, and, I think, represent a fair average as to composition. From these it may be seen that in general a large amount of Al_2O_3 and SiO_2, with small amounts of alkali, or alkali earths, or iron oxide, is characteristic of these highly refractible clays. Further, it seems that a large per cent. of Al_2O_3 over SiO_2 increases the infusibility. However, there seem to be two varieties of fire clay, varying considerably in composition, which make equally good fire brick. One is where the silica is nearly all combined with a percentage of about 40 to 50 per cent, and a large amount of aluminum oxide—probably 25 to 35 per cent.—and water making up the greater amount of the remaining 100 per cent. This clay, of course, as the per cent. of the alumina over the silica and these two over other metallic oxides increases, finally runs into kaolin. The other kind is one where the combined silica is small and the alumina less than in the first case, the combined silica probably not having a much higher percentage than the alumina, the remaining part being made up almost entirely of free silica (quartz sand) and water. No. 2 above illustrates the first and No. 3 the second class.

By comparing the Indianola clays with these it will be seen that the average is essentially the same as No. 1. This being an average of several samples of each of the two classes referred to above, *i. e.*, No. 2 and No. 3. But in the Indianola clays there is but small amount of free silica. This being the case, and from the fact that it is so free from magnesia, lime, potash, and iron oxide, it would seem that this clay would be well adapted to be used as the clay basis of fire brick, and then the necessary amount of free silica (either powdered quartz, glass, or silicious brick dust) be added. By a very careful comparison of all the clays the analyses of which I have, and the qualities of brick made from these, theoretically it seems to me by this means very superior fire brick could be made. The fusibility of bricks made by this method with this clay as far as I know has not been determined. Yet it seems it would be an experiment worth trying, and one which we may attempt at a later date.

I am informed that the pottery made at this plant is not made from the clay at Indianola, but is made from clay taken just above the upper vein of coal at Carlisle, Iowa. I have not analyzed this clay and cannot at present make a comparison.

UNIT SYSTEMS AND DIMENSIONS.

T. PROCTOR HALL.

(*Abstract.*)

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The three fundamental units of the C. G. S. system are reduced to two when the unit of mass is defined as the quantity of matter which, by its gravitational force, produces at unit distance unit acceleration; and these two to one when the unit of time is defined as the time taken by an ether wave one centimeter long to advance one centimeter. A table is given showing the dimensions of units in each of these three systems, and the advantages of the latter are pointed out.

A MAD STONE.

BY T. PROCTOR HALL AND ERNEST E. FRISK.

Here and there is found a man possessing a pebble for which he claims the remarkable power of preventing hydrophobia when applied to the wound made by a mad dog. We have been unable to find any record of a scientific examination of a mad stone or a scientific test of its properties. This may be partly accounted for by the rarity of the stone, and the high esteem in which they are held by their owners. A popular idea is that they are formed by accretion in a deer's stomach.

Last summer while visiting the Mammoth Chimney mine, eighteen miles south of Gunnison, Col., a prospector called attention to some small pieces of light-colored rock from the mine, which adhered very strongly to the tongue. Some

specimens were secured as a curiosity, and after being properly rounded, to obscure their origin, were recognized by some of the "old inhabitants" as genuine mad stones. Their curative power has yet to be tested, but in all other respects, apparently, their identification is complete.

The fragments removed from the larger specimen were preserved for examination and analysis. The specimen itself is larger than a hen's egg, light gray in color, with darker specks of iron scattered through; distinctly stratified; with no cleavage planes. The luster on a broken surface is resinous, on a worn surface more earthy. Its hardness, considered as a rock is $2\frac{1}{2}$, but the fine powder scratches glass. It is infusible in an ordinary blowpipe flame, and powders easily after ignition.

Under the microscope it appears to be made of flat and irregular transparent granules about 1–500 millimeter thick, some of which are ten times that width, fitted loosely together so as to leave irregular cavities everywhere in communication with each other. The fragments resemble fragments of silicious infusorial shells which are found in large quantities in some parts of the Rocky mountains.

The specimen after remaining some weeks in the air of a dry room (heated by hot air) weighed 70.77 grams. It was placed in distilled water, in which it floated for two or three minutes, boiled for some hours, and allowed to cool. After weighing it was hastily dried with a piece of filter paper and weighed again. Lastly it was dried some hours in an oven at a temperature of 100° to 150° C, cooled in a desiccator, and weighed.

Weight in ordinary dry air	70 77 grams.
Weight in water, saturated	39.14 grams.
Weight in air, saturated	115.00 grams.
Weight in air, dry	69.15 grams.

From this data we get:

Volume of rock in the specimen	30 01 cc.
Volume of cavities in the specimen	45.85 cc.
Total volume	75.86 cc.
Specific gravity of rock	2.304
Specific gravity of the whole	.912
Volume of water held in ordinary dry air	1 62 cc.

Some fragments of the stone were pulverized in an agate mortar, fused with sodium and potassium carbonates, and analyzed in the ordinary way. Before fusion the powder was dried at about 150°C. The results are as follows:

	No. 1.	No. 2.
Weight of powder	.5882 gram.	.4559 gram.
$Si O_2$ found	95.53%	96.14%
$Al_2 O_3$ plus traces of $Fe_2 O_3$	4 59%	4.01%
Total	100.12	100 15

The force of adhesion to a wet surface was estimated at 200 grams per square centimeter, or about one-fifth of an atmosphere, but it may be much greater. If applied to a poisoned wound at once it would undoubtedly absorb some of the poison and so assist in the cure. The popular belief in its efficacy has therefore, some foundation in fact.

If more of this rock can be secured it is our intention to test the rapidity of its absorption of moisture from the air when cut in thin slices, with a view to its use as a hygrometer.

The vein in which the specimen was found is twenty feet wide, nearly vertical, and strikes westward. The contents of the vein are chiefly light and dark blue translucent quartzite, mixed with amorphous clay and iron oxide, and bordered by a thin blanket of limestone. Some of the translucent quartzite is mixed with light gray mad stone, as if the firmer portions were formed by fusion of the light gray material. The latter agrees very closely in composition, as well as in appearance, with the silicious shells already mentioned, and was probably formed from them by the internal heat of the vein.

PHYSICAL THEORIES OF GRAVITATION.

T. PROCTOR HALL.

A force which belongs to individual atoms, is independent of chemical and physical conditions, and cannot be altered or destroyed by any known means, must be closely related to the fundamental nature of the atoms. One of the most essential parts in our concept of matter is mass, and the force of gravitation of an atom is proportional to its mass. Mass and gravitation stand, therefore, either as co-effects of the same cause or as cause and effect. The force exerted by each atom at any point decreases in proportion to the increase of the expanding

spherical surface containing the point; following the law of all forces expanding in three-fold space, which may be stated thus: Force x area of distribution=a constant.

From this fact it is evident that the distribution of the force of gravitation is confined to threefold space; for, since the boundary of a fourfold sphere is a solid, a force expanding in all directions from a point in fourfold space decreases in intensity in proportion to the increase of the boundary, that is to say, in proportion to the cube of the radius, instead of following Newton's law.

Newton's law has been experimentally proved for distances that are very great compared with the diameter of an atom, and to a degree of accuracy limited by errors of experiment. It does not necessarily follow that the law holds with absolute accuracy, or that it holds at all for distances comparable with atomic dimensions. All that we can say is that for distances moderate and great the law expresses the facts as accurately as they have been experimentally determined.

Gravitation is not, like magnetism, polar. In crystals atoms have an orderly arrangement, yet no difference has been found in the weight of any crystal when it is set on end or laid on its side. This fact, along with the complete independence of electric conditions, show that gravitation is neither an electric nor a magnetic phenomenon.

The ether, so far as our knowledge goes, is a homogeneous isotropic continuum. In the conveyance of light and of electric strain it shows the properties of an elastic solid. To planetary motions and to ordinary motions on the earth it offers no appreciable resistance, and may therefore be called a fluid. Michelson and Morley have shown that the ether close to and in the earth moves with the earth, which indicates that the ether does not move among atoms without some resistance corresponding to friction. The existence of an ether strain such as that in a leyden jar also shows that there is a resistance on the part of the ether to the kind of motion that takes place in the electric discharge. Ether has mass, since it conveys energy by waves which have a finite velocity. Lord Kelvin has pointed out that the apparently inconsistent properties of the fluid-solid ether are analogous with the properties of ordinary matter. Pitch or taffy, either of which can be bent or moulded easily by a steady pressure, is shattered like glass by a quick blow from a hammer. The ether in like manner yields easily before

moving bodies whose velocity is relatively small, not exceeding a few hundred kilometers per second, but acts as a solid toward such high velocities as that of light, which is nearly 300,000 kilometers per second. Copper, again, is a familiar example of a metal having nearly perfect elasticity within a certain limit of strain. Beyond that limit it yields to pressure like a fluid. The ether shows the same combination of properties with a wider limit of strain. Ether in a vacuum will bear a very great electrical strain without yielding; so that the most perfect vacuum attainable is an all but perfect non-conductor; but if atoms be present the ether gives way to the stress and a current passes very much more readily. This indicates that there is some sort of discontinuity at or near the surface of the atoms.

One of the oldest theories of gravitation was proposed by Le Sage and elaborated by him for a lifetime. He supposed the atoms to have an open structure, something like wire models of solid figures, and to be exposed to a continuous storm of exceedingly minute "ultramundane corpuscles" which he assumed to be flying about in all directions with inconceivable velocity. Two atoms shelter each other from this storm in direct proportion to the quantity of matter in each and inversely as the square of their distance apart, and are therefore driven together in accordance with Newton's law. The ultramundane corpuscles are supposed so small that no atomic vibrations corresponding to heat or light are caused by their impact.

Le Sage's theory is unsatisfactory because it takes no account of the ether, which for such high velocities acts as a solid and would bring the little flying corpuscles to comparative rest in a small fraction of a second.

Kelvin has proposed a modification of Le Sage's theory in order to accommodate it to the existence of the ether. He first showed that vortex rings have some of the properties of elastic solids, and in a perfect fluid would be indestructible; then suggested that atoms may be vortex rings of ether, and the ultramundane corpuscles very much smaller vortex rings having high velocities of translation. In order to account for the permanence of atoms and corpuscles, this view presupposes a practically frictionless fluid ether, which does not at all correspond with the actual ether.

Maxwell, after deducing the mathematical theory of electricity from the hypothesis of ether strain, showed that gravi-

tation also could be accounted for on a similar hypothesis, and that the properties required for the propagation of gravitation are similar to those exhibited by the ether in the phenomena of light and electricity. This theory is the only one that is in harmony with what is known of both gravitation and the ether. It is simple, and makes no assumptions whatever regarding the nature of matter or of atoms. It is incomplete in that it leaves the nature of the strain undetermined.

The non-polar character of gravitation, its symmetry in every way about the atom, reduces to two the possible kinds of strain required by Maxwell's hypothesis. These are displacements of ether radially (1) outward from or (2) inward toward the atom. Assuming, as is customary, that the ether is incompressible, the radial displacement over a spherical surface about the atom is constant; and therefore the displacement and the intensity of the stress at any point varies inversely as the square of its distance from the atom. It is not necessary to suppose, either, that the atom itself is spherical or that the displacements in its immediate vicinity are directed toward or from a single point; for at the distance of a single centimeter from the atom the surface of equal displacement must be so nearly spherical that the most accurate observation now possible would fail to detect any irregularity. Possibly variations in the form of the atom or in the direction of displacement immediately around it may be the cause of the chemical properties of the atom, since these are apparent only at very small distances from it.

For the sake of clearness let us suppose that outward displacement of the ether is caused by the insertion of a quantity of matter, an atom, at any point. Draw a cone having the center of displacement for its vertex. Any small element in this cone is by its outward displacement shortened and widened; so that there is on each end of the conical element a pressure, and in all directions perpendicular to the pressure a tension due to the stretching of the expanded spherical shell containing the element.

Suppose, also, for the sake of clearness, that inward displacement is produced either by cutting out small portions of the ether and leaving holes (atoms) toward which the strain is directed, or by condensing small portions of the ether into atoms. An element of the cone is by its inward displacement lengthened and made narrower, and has a tension on each end and a pressure in all directions perpendicular to the tensions.

The strain in each case extends to infinity, or as far as the ether extends. If the displacement of ether were prevented from extending on one side by a rigid imaginary wall, the whole strain on that side would take place between the atom and the wall, and would be more intense than on the opposite side. The atom would tend to move in such direction as to decrease the intensity of the strain, namely, from the wall if the displacement were outward, toward the wall if the displacement were inward. By the same reasoning two atoms repel each other if the displacement is outward, and attract if it is inward. The law of gravitation is thus explained on the hypothesis that each atom is accompanied by an inward displacement of the surrounding ether, proportional in amount to the mass of the atom.

Minchin (Statics, fourth edition, vol. 2, p. 475,) by a course of mathematical reasoning has reached the same conclusion.

If the atoms be regarded as cavities, the mass of an atom is represented by the quantity of ether removed, which represents also the volume of the atom. Since atomic volume is not proportioned to atomic weight, the cavity-atom hypothesis must be abandoned.

On the condensation hypothesis the mass of an atom is the quantity of ether condensed, its volume the space occupied on the average by the condensed mass which may have any kind of irregularity of form.

This hypothesis implies that all atoms are built out of the same original stuff, and is in this respect similar to but not identical with Prout's hypothesis. The fact that all atoms attract with forces proportional to their masses shows that all atoms possess the same kind of mass, and are therefore likely to consist of the same sort of stuff.

Valence, selective affinity, electric and other peculiarities of atoms, must, if this hypothesis of gravitation be correct, find their explanation in the form and density of the atom, the distribution of its stuff in space, which can be expressed as a function of the three space co ordinates; together with the laws of energy, which express the relations of the atom to the ether. The field of force about an atom is also capable of representation by a function of the space co-ordinates such that when the distance r from the atom is relatively great the equipotential surfaces are very nearly spheres.

Stress in its ultimate analysis is probably dynamic. If so, the maintenance of the field of strain about an atom as it moves presents no greater difficulty than the maintenance of the field of light about a moving candle, or of the field of sound about a moving bell.

The propagation of such ether strains as occur in light, electricity and magnetism is very greatly influenced by the material substances present in the strained medium. It is not probable that the gravitational strain differs from others in this respect, and we may reasonably hope to find some inductive phenomena in connection with gravitation. A feasible plan is to surround a delicately poised mass by a thick pair of hemispheres (which may be hollow for liquids), and note with a refractometer any change of position, which, since the attraction of a sphere at a point within it is zero, will be due either to induction or to irregularities of the sphere. Errors due to irregularities may be readily eliminated by rotating the sphere.

THE LE CLAIRE LIMESTONE.

BY SAMUEL CALVIN.

The Le Claire limestone constitutes the second stage of the Niagara formation as it is developed in Iowa. The first or lower stage has been called the Delaware, from the fact that all its varying characteristics are well exhibited in Delaware county. The Delaware stage embraces many barren beds and presents a very great number of phases, but at certain horizons it abounds in characteristic fossils. The typical faunas of this lower stage embrace such forms as *Pentamerus oblongus* Sowerby, *Halysites catenulatus* Linnæus, *Favosites favosus* Goldfuss, *Strombodes gigas* Owen, *Strombodes pentagonus* Goldfuss, *Ptychophyllum expansum* Owen, and *Diphyphyllum multicaule* Hall. The beds of the Delaware stage furthermore contain large quantities of chert.

The Le Claire stage of the Niagara follows the Delaware. The exact line of separation between the two stages has not been, and probably cannot be, definitely drawn. There are

massive, barren, highly dolomitized aspects of both stages that, taken by themselves, cannot be differentiated in the field. Under such circumstances the observer must work out the stratigraphic relations of the particular group of strata under consideration before referring it to its place in the geological column. In general the Le Claire limestone is a heavy bedded, highly crystalline dolomite. It contains scarcely any chert, and in the lower part there are very few fossils. There are occasionally a few specimens of Pentamerus, of the form described as *Pentamerus occidentalis* Hall, and the principal coral is a long, slender, tortuous Amplexus which is represented only by casts of the vacant or hollow parts of the original corallum. On account of the complete solution of the original structure, the spaces occupied by the solid parts of the corallum are now mere cavities in the limestone. In the upper part of the Le Claire stage small brachiopods abound. They belong to the genera Homeospira, Trematospira, Nucleospira, Rhynchonella, Rhynchotrepa, Atripa, Spirifer, and probably others. In most cases the fossils have been dissolved out, leaving numerous cavities. The calcareous brachial apparatus of the spire bearing genera is often the only part of the original structure represented. No statement can well give any idea of the numbers of the small shells that crowded the sea bottom near the close of the Le Claire stage, nor of the corresponding number of the minute cavities that are now so characteristic a feature of this portion of the Le Claire limestone. In some localities in Cedar county the small brachiopods of this horizon are represented by very perfect casts that were formed by a secondary filling of the cavities left by solution of the original shell. The external characters are thus fairly well reproduced.

Compared with the beds of the Delaware stage, the Le Claire limestone as a rule lies in more massive ledges, it is more completely dolomitized, and its fracture surfaces exhibit a more perfect crystalline structure. It contains an entirely different fauna, a fauna in which small rhynchonelloid and spire-bearing brachiopods are conspicuous. Its fossils are never silicified, and, in marked contrast with some portions of the Delaware, its upper part at least is notably free from chert. The Le Claire limestone is the lime burning rock of Sugar Creek, Cedar Valley, Port Byron, and Le Claire. Wherever it occurs it furnishes material for the manufacture of the highest quality of lime.

With respect to their distribution the strata of this stage are well developed at Le Claire in Scott county. They are seen in the same stratigraphic relation at the lime kilns on Sugar creek and at Cedar Valley in Cedar county. They occur beneath the quarry stone at and near Stone City, Olin, and Hale in Jones county. They are again seen at numerous points west of the Jones county line in Linn. Indeed they are somewhat generally, though by no means universally, distributed in the east central part of Scott, southwestern parts of Clinton, western Cedar, and the southern parts of Jones and Linn. They seem to be limited to the southwestern corner of the Niagara area. A line drawn from the mouth of the Wapsipinicon through Anamosa would mark approximately their northeastern limits.

The Le Claire limestone is in some respects unique among the geological formations of Iowa. In the first place it varies locally in thickness, so much so that its upper surface is exceedingly undulating, the curves in some places being very sharp and abrupt. In the second place it differs from every other limestone of Iowa in frequently exhibiting the peculiarity of being obliquely bedded on a large scale, the oblique bedding often affecting a thickness of fifteen or twenty feet. The phenomena suggests that during the deposition of the Le Claire limestone the sea covered only the southwestern part of the Niagara area, that at times the waters were comparatively shallow, and that strong currents, acting sometimes in one direction and sometimes in another, swept the calcareous mud back and forth, piling it up in the eddies in lenticular heaps or building it up in obliqely bedded masses over areas of considerable extent. The oblique beds observe no regularity with respect to either the angle or direction of dip. Within comparatively short distances they may be found inclining to all points of the compass. Again the waters at times were quiet, and ordinary processes of deposition went on over the irregular sea bottom, the beds produced under such circumstances conforming to the undulating surface on which they were laid down. In some cases these beds were horizontal as in the upper part of the section illstrated in plate 1, while in other cases they were more or less flexuous and tilted as seen in the left bank of the Wapsipinicon above Newport. (Figure 2.)

Professor Hall accurately describes some of the variations in the inclination and direction of dip in the Le Claire limestone

FIGURE 1. Exposure of LeClaire limestone at the Sugar creek lime quarries, Cedar county, Iowa. The limestone is obliquely bedded in the lower part of the section and horizontally bedded above. The same fauna occurs in both sets of beds. Oblique beds dip southeast.

FIGURE 2. Oblique beds of LeClaire limestone, dipping northeast, in west bank of Mississippi river, one-half mile below LeClaire, Iowa.

as seen at Le Claire*, but he assumes that the inclination of the beds is due to folding and uplift subsequent to their deposition. On this assumption the Le Claire limestone would have a thickness of more than 600 feet, whereas the maximum thickness does not exceed 80 feet, and the average over the whole area is very much less. Prof. A. H. Worthen† studied this limestone at Port Byron, Ill., and Le Claire, Iowa, and describes it as "presenting no regular lines of bedding or stratification, but showing lines of false bedding or cleavage at every conceivable angle to the horizon." He assigns to these beds a thickness of

FIGURE 2. Inclined undulating beds of the Le Claire stage near Newport, Iowa.

fifty feet, but he offers no explanation of what he calls "false bedding or cleavage." In White's report on the geology of Iowa‡ the oblique bedding seems to have been taken as evidence that a line of disturbance crossed the Mississippi river at Le Claire with a direction nearly parallel to the Wapsipinicon valley. This apparent disturbance was last recognized about three miles west of Anamosa. The angle of dip it is said has reached in some places twenty-eight degrees with the horizon. McGee in discussing the *Regular Deformations of Northeastern Iowa*§ quotes Dr. White on the Wapsipinicon line of disturbance

* Rept. on the Geol. Surv. of the State of Iowa, Hall and Whitney, vol. I, part I, pp. 73–74. 1858.

† Geol. Surv. of Ill., vol. I, p. 130. 1865.

‡ Rept. on the Geol. Surv. of the State of Iowa, Charles A. White, vol. I, p. 133. 1870.

§ Pleistocene history of Northeastern Iowa, p. 340. 1891.

and accepts the observations on which the statement is based as evidence of a synclinal fold extending from Le Claire to Anamosa. White's observations appear to have been made only at the two points mentioned. At both places the strata seem to be inclined at a high angle. On the assumption that the inclination of the strata indicates orogenic disturbance, the conclusion that the disturbed beds were parts of the same fold was very natural. There is, however, no fold, nor is there any line of disturbance. In the whole Niagara area southwest of the line which marks the limit of the Le Claire limestone the phenomena seen at Le Claire and west of Anamosa are repeated scores of times and in ways that defy systematic arrangement. The beds incline at all angles from zero to thirty degrees, and even within short distances they may be found dipping in every possible direction. Twenty miles southwest of the line supposed to be traversed by the synclinal fold, for example at the lime kiln on Sugar creek, along the Cedar river above Rochester, at Cedar Valley, as well as at many intermediate points distributed promiscuously throughout the area of the Le Claire limestone, the beds stand at a high angle, and the multiplicity of directions in which they are inclined, even in exposures that are relatively near together, is wholly inconsistent with the idea of orogenic deformation. The beds are now practically in the position in which they were laid down in the tumultuous Niagara sea. The principal disturbances they have suffered have been the results of epeirogenic movements which affected equally the whole region over which these limestones are distributed, as well as all the adjacent regions of the Mississippi valley.

The exposures at Port Byron and Le Claire present some interesting features that are not seen so well at any of the exposures farther west. In the first place, the lime quarries at Port Byron show the characteristic oblique position of the strata, and at the same time they demonstrate that the oblique bedding is real and not a mere deceptive appearance due to cleavage of a mass of sediment that was originally built up regularly and evenly on a horizontal base. As in other groups of strata, there are faunal and lithological variations when the beds are compared one with another. These varying characteristics do not intersect the beds in horizontal planes as they would if the present bedding were due to cleavage of a mass that had risen vertically at a uniform rate, but they follow the

FIGURE 1 Thin-bedded LeClaire limestone overlying the phase represented in Plate I, figure 2, as seen on west side of Main street, LeClaire, Iowa At this point sub-marine erosion removed portions of certain beds, and the space so formed was subsequently filled with a second set of beds which overlapped obliquely the eroded edges of the first.

individual layers in their oblique course from top to bottom of the exposure. The facts confirm the statement that the beds were deposited one by one in the position in which we now find them.

On the west side of the Mississippi, south of Le Claire, the usual oblique bedding is seen in the bank of the river, below the level of the plain on which the lower part of the town is built. The individual beds, as in all the characteristic exposures of this formation, range from eight to twelve inches in thickness. Above the level of the beds exposed in the river bank there is another series of Le Claire beds that depart somewhat from the ordinary type. Near the base of this second series the layers are thick and the rock is a light gray, porous, soft, non-crystalline dolomite. These grade up into thinner and more compact beds, but the lithological characters are never quite the same as those of the more typical beds at a lower level. The soft, porous gray-colored beds contain casts of *Dinobolus conradi* (Hall). The same species ranges up into the harder beds, but the characteristic fossils above the soft, porous layers are casts of small individuals of *Atrypa reticularis* and a small, smooth-surfaced Spirifer. The layers become quite thin in the upper part of the Le Claire. They show many anomalies of dip, but, so far as observed, they do not as a rule stand at as high angles as do the harder and more perfectly crystalline beds of the lower series. The existence, however, of tumultuous seas is no less clearly indicated at this horizon than in the lower beds that pitch at greater angles. In the town of Le Claire, on the west side of the main street, there is evidence of the erosion of the sea bottom by currents, and subsequent filling of the resulting channels with material of the same kind as formed the original beds. In eroding the observed channel some of the previously formed layers were cut off abruptly, and in refilling the space that had been scooped out the new layers conformed to the concave surface and lapped obliquely over the eroded edges of the old ones.

The angle at which the lower, more highly inclined beds stand never exceeds twenty-eight or thirty degrees; that is, it never exceeds the angle of stable slope for the fine, wet, calcareous material of which the strata were originally composed.

The Le Claire limestone is, as a whole, sharply set off from the deposits of the Delaware stage by its hard, highly crystalline structure, its freedom from chert, its easily recognized

fauna, and its record of anomalous conditions of deposition. In the field the distinction between the Le Claire and the Anamosa stages are even more easily recognized, though faunally the two stages are intimately related. In the Anamosa stage oblique bedding is unknown; lithologically the rock is an earthy, finely and perfectly laminated dolomite, not highly crystalline in its typical aspect, and too impure for the manufacture of lime. It may be quarried in symmetrical blocks of any desired dimensions, while the Le Claire limestone breaks into shapeless masses wholly unfit for building purposes. The quarry beds of the Anamosa stage are quite free from fossils, but along the Cedar river in Cedar county the brachiopod fauna of the upper part of the Le Claire reappears in great force in a stratum four feet in thickness, up near the top of the formation. The beds of the Anamosa stage are very undulating, and dip in long, graceful, sweeping curves in every possible direction. The knobs and bosses and irregular undulation developed on the sea bottom as a result of the peculiar condition prevailing during the Le Claire age, persisted to a greater or less extent after the age came to an end, and it was upon this uneven floor that the Anamosa limestone was laid down. The puzzling flexures of the Anamosa limestone, and the puzzling variations in altitude at which it occurs, were largely determined by irregularities in the upper surface of the Le Claire formation.

THE BUCHANAN GRAVELS: AN INTERGLACIAL DEPOSIT IN BUCHANAN COUNTY, IOWA.

BY SAMUEL CALVIN.

About three miles east of Independence, Iowa, there are cross-bedded, water-laid deposits of sand and gravel of more than usual interest. The beds in question occur near the line of the Illinois Central railway. The railway company indeed has opened up the beds and developed a great gravel pit from which many thousands of carloads have been taken and used as ballast along the line.

Overlying the gravel is a thin layer of Iowan drift, not more than two or three feet in thickness, but charged with gray

granite boulders of massive size. Some of these boulders may be seen perched on the very margin of the pit, and some have been undermined in taking out the gravel and have fallen to the bottom. The surface of the whole surrounding region is thickly strewn with Iowan boulders. It is evident that the Iowan drift sheet was spread over northeastern Iowa after the gravels were in place.

These sands and gravels are now so incoherent that they may be excavated easily with the shovel, and yet there is no evidence that the glaciers that transported the overlying boulders and distributed the Iowan drift cut into them, or disturbed them, to any appreciable extent. The Iowan ice sheet was probably thin, and all the loose surface materials in front of its advancing edge were frozen solid. The thickness of the gravels is somewhat variable, owing to the uneven floor upon which they were deposited, but it ranges from fifteen to twenty feet. The beds have been worked out in places down to the blue clay of the Kansan drift.

Throughout the gravel bed, but more particularly in the lower portion of it, there are numerous boulders that range in diameter up to ten or twelve inches. These boulders are all of the Kansan type. Fine grained greenstones predominate. Proportionally large numbers of them are planed and scored on one or two sides. Those that are too large to be used as ballast are thrown aside on the bottom of the excavation, and in the course of a few seasons many of the granites and other species crumble into sand. The contrast between the decayed granites of the Kansan stage and the fresh, hard, undecayed Iowan boulders in the drift sheet above the gravels, is very striking. Many of the boulders from the gravels are coated more or less with a secondary calcareous deposit, a feature not uncommon among boulders taken directly from the Kansan drift sheet in other parts of Iowa.

As to their origin the Buchanan gravels are made up of materials derived from the Kansan drift. As to age they must have been laid down in a body of water immediately behind the retreating edge of the Kansan ice. There are reasons for believing that the Kansan ice was vastly thicker than the Iowan, but the temperature was milder, and so when the period of melting came enormous volumes of water were set free. That strong currents were developed is evidenced by the coarse character of the material deposited as well as by the conspicuous

cross bedding that characterizes the whole formation. Some of the larger boulders found at various levels throughout the beds were probably not directly transported by currents, but by floating masses of ice. While, therefore, the gravels lie between two sheets of drift, and for that reason may be called interglacial, probably Aftonian, they yet belong to the time of the first ice melting, and are related to the Kansan stage of the glacial series as the loess of northeastern Iowa is related to the Iowan stage.

While the Illinois Central gravel pit is the typical exposure of the Buchanan gravels, the same beds are found widely distributed throughout Buchanan, Linn, Jones, Delaware and probably other counties. One exposure that has been utilized for the improvement of the county roads occurs on the hilltop a mile east of Independence. Another, used for like purposes, is found a mile and a half west of Winthrop. The county line road northeast of Troy Mills cuts through the same deposit. Throughout the region already indicated there are many beds of similar gravels, but in general they are so situated as not to show their relations to the two beds of drift.

The Buchanan gravels, it should be remembered, represent the coarse residue from a large body of till. The fine silt was carried away by the currents and deposits of it should be found somewhere to the southward. It may possibly be represented, in part at least, by the fine loess-like silt that forms a top dressing to the plains of Kansan drift in southern Iowa and regions farther south.

RECENT DISCOVERIES OF GLACIAL SCORINGS IN SOUTHEASTERN IOWA.

BY FRANCIS M. FULTZ.

The discoveries of localities showing glacial scoring in southeastern Iowa have been somewhat numerous during the last few years. In a paper presented before this body a year ago[1] I called attention in detail to the different known exposures

[1]Glacial Markings in Southeastern Iowa. Proc. Ia. Acad. Sci., Vol. II, p. 213. Des Moines, 1895.

FIGURE 1. General view of the typical exposure of the Buchanan gravels.

FIGURE 2. Near view of the Buchanan gravels.

FIGURE 1. Abandoned part of gravel pit.

FIGURE 2. Field immediately north of the gravel pit showing large numbers of Iowa boulders.

of glaciated rock in this region, and pointed out that the testimony they gave was unanimous as to the southeastern movement of the ice sheet. Since then another exposure has been located that seems to bring conflicting testimony.

This locality is the joint discovery of Mr. Frank Leverett and myself. It is situated on the lot at the northeast corner of the intersection of Court and Prospect streets in the city of Burlington. Some quarrying had been done by blasting out the level rock floor. Everywhere on the margin of the hole thus formed may be seen the finely striated and grooved surface. On the east side a patch, 6x8 feet, was cleaned off and a finely striated surface brought to view. The direction of the striæ, taken with compass and corrected, was S. 79° W. This would indicate an almost due westerly movement, which is in direct variance with that shown by all other discoveries of glaciated rock in this region. If *direction of strice* alone were taken into consideration, then it might be claimed that the ice movement in this case also was towards the east. But a close and critical examination shows that all the accompanying phenomena point to a westerly trend; *e. g.*, the indicated movement of the ice around and over a prominence, and down into and out of a depression.

This is new and important evidence that the Illinois lobe of the great ice sheet crossed the Mississippi river and invaded Iowa. It will be remembered that I presented a paper on this subject at our last meeting.[2] The evidence on which the claim was based was the presence, on the Iowa side, of boulders of Huron conglomerates. I was convinced that this westward movement was not the *latest* in this region, but that the ice moving from the northeast was the last to hold possession of the west bluff of the Mississippi; and I so put forward in the paper. Mr. Frank Leverett, who has made an exhaustive study of this question, is of the opinion that the Illinois ice sheet was the last to invade this portion of Iowa, and that the movement extended to some twenty miles west of the river. This recent discovery of glacial scoring certainly strengthens his theory. For it is situated at such an elevation that any ice sheet passing over would be almost certain to leave its impress; and therefore the striæ we now find are very apt to be those made by the latest invasion.

[2]Extension of the Illinois Lobe of the Great Ice Sheet Into Iowa. Proc. Ia. Acad. Sci., Vol. II, p. 209. Des Moines, 1895.

However, I am not yet fully convinced. Of the somewhat numerous discoveries of glacial scorings in this region, nearly all are on the very brow of the west bluff bordering the Mississippi flood plain, where they would offer the best possible opportunity for erosion. It would therefore seem that they ought to be the records of the *very latest* invasion. And all these, without a single exception, show southwestward movement.

SOME FACTS BROUGHT TO LIGHT BY DEEP WELLS IN DES MOINES COUNTY, IOWA.

BY FRANCIS M. FULTZ.

During the past year a number of deep wells were sunk in Des Moines county. Some of them reached such extraordinary depths before touching rock, or without touching rock at all, as would clearly show the presence of buried river channels.

In a paper presented before this society a year ago I stated that the preglacial and present drainage systems in this region were practically the same. From facts recently brought to light I must necessarily change that opinion. To what extent remains yet to be seen.

My attention was first called to the presence of buried water courses in this locality by Mr. Frank Leverett, of the United States Geological Survey, who has collected a large mass of data on the glacial phenomena of this region. He has already given us a general discussion of the preglacial conditions of the Mississippi basin[1]; and in the course of time we may hope for further and more detailed contributions along the same line.

The deep wells in question are located some eight or nine miles north of Burlington. One is on the farm of L. Aspelmeier, near Latty station. It is 233 feet deep, and penetrates the rock but two feet. Unfortunately there was no record kept of the character of the deposits passed through, which is also true of the other wells to be mentioned further on. Therefore the details are somewhat meager. As nearly as could be determined the till continued to a depth of 188 feet, where a gravel

[1] Journal of Geology, p. 740, Vol. III, No. 7, 1895.

bed of several feet in thickness was passed through. In this gravel deposit well preserved bones were found. They were crushed into fragments by the drill, but a number of pieces, from one inch up to three inches long, were brought up in the wash. I saw these fragments about a week after they were discovered, and they had the appearance of having belonged to a living animal not longer ago than that time. Mr. Jennings, of New London, Iowa, who had charge of the drilling, told me that the bones had quite a fetid odor when first brought up. It was difficult to determine from what particular bones the fragments were, but I would place them as parts of the leg bones of some animal of slender build. Below the gravel bed the drill passed through a black deposit, which the well drillers call "sea mud," and which rests directly upon the blue shale of the Kinderhook, 231 feet below the surface.

A quarter of a mile north of the Aspelmeier well the rock bed is reached at a depth of less than thirty feet. It is the hard, compact limestone of the Upper Burlington. This shows a drop of over 200 feet in within a distance of 80 rods.

Half a mile south of the Aspelmeier well, on the farm of Fred Timmerman, there is another deep well which reaches a depth of 184 feet without striking rock. The bottom of the well is in a gravel deposit, which partakes of the nature of a forest bed. From it much woody matter was brought up.

A half mile still further south, making a mile south from the Aspelmeier well there is still another deep well. It is on the place of H. C. Timmerman. It reaches a depth of 188 feet without striking rock. It likewise terminates in a gravel bed containing much woody matter. In the two Timmerman wells the water rises seventy-five feet. When last heard from the Aspelmeier well was not furnishing a satisfactory supply.

These wells indicate an old channel of great depth, and of not less than a mile and a quarter in width. The width is probably much greater. Mr. Frank Leverett suggests that this ancient river bed was the water outlet of part of the territory now drained by the Skunk river.

RECENT DEVELOPMENTS IN THE DUBUQUE LEAD AND ZINC MINES.

BY A. G. LEONARD.

During the past year or two there have been some important developments in the Dubuque district. New lead mines have been opened up, new ore bodies have been discovered, and the Durango zinc mine, the largest in the state, has been still further developed.

About one mile west of the city is located the mine of the Dubuque Lead Mining company, which has been worked only about a year and a half. It is on the west end of the old level range which has been followed for nearly three miles and has yielded considerable ore from various points along its length. When the mine was visited in November, 1895, there were seventy-five men employed and the place presented a lively appearance. The three shafts are 210 feet deep with a steam hoist on one and gins on the other two. The company has just erected a concentrator at the mine for the purpose of crushing and cleaning the ore. This was made necessary by the fact that in this mine much of the Galena occurs scattered through the rock, sometimes in particles of considerable size. The limestone is crushed and the lead then separated from it by washing. The ore-bearing dolomite forms a zone from two to four feet wide and contains an abundance of iron pyrites. This latter mineral is often found here crystallized in beautiful octahedrons with a length of from one-fourth to three-fourths of an inch. Besides being disseminated through the rock the Galena occurs in large masses in what is probably the fourth opening, and it likewise fills the crevice above for some distance. The ore body is apparently an extensive one; 700,000 pounds of lead have already been raised. Work in this mine is made possible only by the constant operation of a steam pump which keeps the water below the opening where the ore occurs and thus allows the miners to reach the deposits.

The extensive zinc mine at Durango, five miles northwest of Dubuque, has several points of special interest. The timber range on which the diggings are located was once well known as a large lead producer. The range has a width of 100 feet, and is formed by three main crevices, with a general direction S. 80° E. The openings occur ninety feet below the crown of the hill, and where they are enlarged the three fissures unite in caverns of immense size. In these openings the lead occurred, and above them, extending to the surface, the hill is filled with zinc carbonate. The zinc is known to extend also below the level of the lead. The mine is worked by means of an open cut extending through the hill, with a width of forty feet and a depth of about eighty feet. The crevices are more or less open up to the surface. Several can be seen in the face of the cut, and in them the ore is most abundant, though it is also found mixed all through the fractured limestone. The strata have been subjected to more or less strain, possibly owing to the large caves below, and are broken into fragments. The carbonate is found coating these pieces and filling the spaces between, occurring also, as stated, in the open crevices. The latter have a width of from one to two feet. In working the mine the larger masses are blasted and the smaller ones loosened with the pick. The ore is removed from the rock, the latter is carted off to the dump, and the dry bone, mixed with more or less waste material, is carried to a neighboring stream. Here it is washed by an ingenious contrivance which thoroughly frees the ore from all sand and dirt. The method was invented by Mr. Goldthorp, superintendent of the mine, and is quite extensively used about Dubuque. An Archimedes screw, turned by horse power, revolves in a trough through which a stream of water is kept flowing. As the screw revolves it gradually works the ore up the gentle incline, while the water runs down and carries with it all sand and dirt. Afterwards the dry bone is picked over by hand and the rock fragments thus separated.

During the past season eighteen men were employed at the mine and the daily output was from fifteen to eighteen tons of ore. This would mean a yield of over 2,500 tons for six months, and is probably about the annual production of the mine during the last few years.

Most of the zinc mines have been closed for nearly two years on acount of the low price paid for the carbonate, the average being only $5 to $6 per ton the past year. About 800 tons

were, however, sold at these figures. There are very large quantities of ore in sight in these mines, as even a brief inspection clearly shows, and they are capable of yielding thousands of tons for some years to come.

The output of the mines for the past year can be given only approximately. They have produced about 750,000 pounds of lead and from 3,000 to 3,500 tons of zinc. But it must be remembered that, as already stated, most of the zinc mines were closed during the past season. They are easily capable of yielding from 8,000 to 10,000 tons of ore annually.

THE AREA OF SLATE NEAR NASHUA, N. H.

BY J. L. TILTON.

OUTLINE.

Maps of Crosby and Hitchcock.
The area briefly outlined.
Description of the slate area.
Description of the rocks.
  Section from Nashua northward.
  Section along the Massachusetts line.
  Section west of Hollis Center.
  Section east from Runnells Bridge, and southeast from Nashua.
Attempt to harmonize descriptions of Crosby and Hitchcock.
Structure.
  Dip, strike, general section.
Evidences of faults.
Cause of metamorphism.

Maps of Crosby and Hitchcock.—Crosby's map of eastern Massachusetts represents an area of slate, or argillite, as it is termed, running from Worcester through Lancaster and Pepperell to the New Hampshire state line. The eastern part of this argillite, two and one-fourth miles wide on the map, but four miles wide according to the text,* continues north into New Hampshire just west of the Nashua river. On the east of the argillite lies mica schist in an area very narrow (three-fourths of a mile) near the state line, but much wider toward the southern part of the township of Dunstable. On the west

*Crosby's "Geology of Eastern Massachusetts," p. 137.

of the argillite lies gneiss close to the state line, but mica schist a little farther southwest (in Townsend).

Hitchcock's geological map of New Hampshire (Rockingham Sheet) represents an island of gneiss extending from Mine Falls to a mile south of the Massachusetts line near Hollis Station (occupying a part of the area where Crosby locates argillite). This island lies in "Rockingham Mica Schist," extending along the northwest side as an area three and three-fourths miles wide, on the average, and along the southeast side as an area two and a half miles wide. Both these areas of mica schist are represented as continued toward the northeast across the Merrimac river and southwest into Massachusetts.

It is the object of this paper to mark out and describe the slate rock in the vicinity of Nashua (Crosby's argillite, or the northern of the two areas marked by Hitchcock as mica schist).

The Area Briefly Defined.—The slate rock is found to lie in an area six miles wide extending northeast-southwest, just northwest of the Nashua river.

Along the southeast of this area the contact between the slate and the adjacent schist and gneiss extends from Runnells' bridge in a northeasterly direction parallel with the general course of the Nashua river as far as Nashua, where the river leaves the vicinity of the contact. In the city of Nashua the contact extends northwestward in a line between Shattuck's ledge and the reservoir.

Along the northwest of this slate area the boundary-line extends from where Gulf brook crosses the slate line, northeastward through the valley just east of Proctor Hill, near Long pond, Pennichuck pond and Spaulding's pond (or Reed's pond, as it is called locally) and crosses the Merrimac river a mile below Thornton's ferry. This line is not perfectly straight but curved slightly with the convex side to the northwest. Just north of Gulf brook the line curves somewhat suddenly toward the southwest, passing between the two exposures half a mile northeast of the mouth of Gulf brook.

Southeast of Nashua no slate was found in the area represented on Hitchcock's map as a branch of this slate there marked "Rockingham Mica Schist."

General Description of the Slate Area.—The area of slate is marked by an extent of lowland occupied partly by swamps

and ponds.* It contains the Nissitisset river, Flint pond, Long pond, Parker's pond, Pennichuck pond, Round pond and Spaulding's pond, besides a large area of swamp. The southeastern part of the slate area is largely occupied by the present valley of the Nashua.

Within this area the hills of slate rise in ridges to a height of one hundred feet above the adjacent lowland. They do not form continuous ridges, nor does their general direction conform to the direction of strike. This general direction is N. 70° E., while the strike is on the average N. 57° E., though the strike varies a few degrees even in strata but a few feet apart, as the rock is much contorted. These hills are low in contrast with the hills in the gneiss and schist area adjoining. From the top of Long Hill, a hill of the Monadnock type just south of Nashua, these slate hills appear below the Cretaceous peneplain.

The valleys between these hills, even the hills themselves, are mantled with drift, and the river valleys deeply covered with washed drift; but further reference to this important feature is here omitted as not a part of the problem under consideration.

Description of the Rocks.—The character of the rocks and the relation of them one to another is perhaps best seen along a line from Shattuck's ledge, Nashua, northwestward. At Shattuck's ledge, the rock is gneiss in part heavy, in part quite schistose.

At the reservoir, three quarters of a mile west, occurs slate with bands of graphite. Northwest for three miles the rock is a slate very much crushed and crumpled, and in the northern part of this area, a shaly slate interbedded with gneiss. The dividing lines, then between the slate and the schist, and between the schist and the gneiss, are not definitely marked lines, but are intermediate places in a series of gradations.

Similar gradations from slate through schist to gneiss are to be found in the southwestern part of the area near the confluence of Gulf brook and Nissitisset river. Here, south of the Massachusetts line, the slate is both shaly and quartzose. Just north of the Massachusetts line quartz veins are very marked in a dark schistose rock. This same structure is found in a railroad cutting near by, revealing in an excellent manner

*The contour lines of the accompanying map are as given on the New Hampshire state geological atlas.

the schistose structure with quartz veins. A little farther northwest gneiss appears instead of schist. Here, then, there is a passage from slate through schist to gneiss.

Just west of Hollis Center is still another opportunity to observe an approach to the dividing line between the slate and the schist, though not so good as either of the two already described. Just west of Hollis Center there is slate. This grades through schist to the gneiss quarried at Proctor Hill.

Southeast of the slate area are several outcrops of gneiss: one at Shattuck's ledge in the northeastern part of the city of Nashua, another in the western part of the city, where it is quarried in one place, a third on the Nashua river, five miles above Nashua, a fourth at Flat Rock quarry, and again at Long Hill, south of the city.

The sudden transition from slate to gneiss close to the Nashua river will be referred to under the heading "Faults."

Eastward from Runnells' bridge, near Hollis, there is a gradation from the slate through schist to the gneiss at Flat Rock quarry, and a similar gradation from schist to gneiss between Nashua and Long Hill.

Thus southeast there is a gradation from slate through schist, schist with quartz seams to gneiss, similar to that from the slate area northwest.

Attempts to Harmonize Descriptions of Crosby and Hitchcock.— The above description of gradations in the character of the slate, schist and gneiss, suggests an explanation of an apparent lack of harmony between Crosby and Hitchcock. Crosby distinctly records gradation between the three rocks, and because of this gradation seems to call both the slate and the schist argillite, even though the argillite southeast of Nashua is exceedingly clear mica schist. Judging by the map, Hitchcock apparently recognizes the same gradation between the rocks, though I find no description in the text to confirm this inference, and calls both schist. I fear, however, that because of the schistose character of many of the slate outcrops, the area of slate has been entirely neglected.

Concerning Hitchcock's location of the gneiss area along the Nashua river, between Mine Falls and just south of the state line, there is a single area of probable gneiss on the river about four miles west of Nashua. This area is cut off on the southwest by slate just south of Runnells' bridge, and on the northeast by mica schist at Mine Falls. Hitchcock has overlooked

the gneiss east of Mine Falls, where two areas exist: one a mile west of Nashua (Main street) and south of the canal, where outcrops occur at a large quarry, and in the hill just west of the cemetery. The other area omitted is in the northeastern part of the city itself, at Shattuck's ledge, near the Merrimac river, a mile and a half from the outcrops just west of the city.

It is possible that these two areas should be classed as one, since no outcrops exist between the two areas to tell what the rock between them may be.

The line bounding Hitchcock's "Rockingham Mica Schist" seems to indicate the line between schist and gneiss, as if he did not recognize the slate as a separate rock from the schist. My northwestern line bounding the slate lies about parallel to his line bounding the Rockingham Mica Schist and a mile to the southeast of it.

Strike.—On the map accompanying this paper numerous dips and strikes may be found recorded. It now becomes necessary to observe their relation to determine what folds may exist in the area, for there are no strata within the slate area itself whose repetition can indicate the structure.

Within the slate area and in the gneiss along the northwestern boundary the strikes measured are much the same. North of Nashua there is slight evidence that the anticline there tends to form a nose; but all other variations from N. 33° E. are such

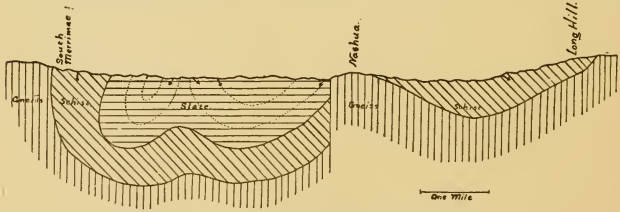


FIGURE 3. Section northwest-southeast across the area.

as a badly crushed area might represent; variations too small to be systematized even by minute observations at all points. This general similarity of strike indicates horizontal folds extending in the direction of the strike.

A study of the dip along lines at right angles to the strike reveals the anticline of a fold running in the direction of the strike along the western half of the slate, while a syncline runs along the eastern half. These are here represented in a diagram. (Fig. 3.)

Faults.—At the reservoir in Nashua are evidences of a fault; there is in the slate a seam of graphitic slate with veins of quartz near by. In this graphitic slate much crushing and slipping has occurred. The strata are on edge with strike N. 73° E.

The argument for a fault in this locality is sustained, in fact made necessary, by the structure of the region. The general succession of strata from southeast to northwest, is gneiss, schist, slate, schist, gneiss, with no evidence of unconformity; but at Shattuck's ledge the gneiss appears in close proximity to the slate, with little chance for schist between. The dip at Shattuck's ledge compared with the dip observed in the schist to the south indicates that the gneiss exposed at Nashua is in an anticline.

North of the gneiss at the quarry just west of Nashua a fault is possible, but not necessary to explain the structure, if schist not exposed underlies the river valley. While schist occurs at Mine Falls, schistose gneiss occurs two miles farther west with no schist that is exposed to the north, and beyond Runnells' bridge the eastern boundary of the slate area bends southeastward across the line of strike. Thus while the evidence of faulting is very marked near Nashua it becomes less marked southwestward.

Other evidences of faulting exist near the mouth of Gulf brook, and just west of Hollis Center. Along this line the presence of slickensides in graphitic slate, with quartz seams near by, indicate that a line connecting these two points is a line of faulting.

Cause of Metamorphism.—Finally, it remains to ascertain the cause of the metamorphism. This involves a petrographical problem, especially on the gneiss. There is no igneous rock to be found in the area, unless the gneiss itself be of igneous origin.

If the gneiss itself is not of igneous origin there may be igneous rock not far below, or not far beyond the margins of the area, though no locality of such minerals as are common where igneous material comes in contact with sedimentary material is here to be found, nor is there any evidence of intense heat.

Regional metamorphism affords a satisfactory explanation. The intense crumpling of the strata, the steep dip, the bands of quartz alternating with the slate along the margins of the gneiss, with lack of evidence of intense heat in the immediate vicinity, all indicate that the metamorphism is regional.

NOTES ON THE GEOLOGY OF THE BOSTON BASIN.

J. L. TILTON.

The region about Boston forms a basin. Standing on the reservoir at College Hill one looks north, west and south upon lines of hills surrounding Boston and the thickly populated adjoining country. In the relation of the rocks underlying the drifts this region also forms a basin. The distant hills are of hornblende granite extending from near Marblehead southwest to near south Natick, thence east toward Quincy. Close to this granite area are other igneous rocks, and within the basin, conglomerate and slate so related and concealed by drift as to present many difficult problems.

It is not surprising that the discussion* of the area contains not only a mass of conflicting conclusions, but even a mass of conflicting statements concerning field evidence. The rocks seemed to grade into one another; the felsite along the margin of the basin appeared where observed to penetrate the granite instead of the granite the felsite; the flow structure seemed stratification; the sedimentary material is so related to the igneous rock and presents plains of stratification so obscure and nearly vertical that to some the conglomerate appeared uppermost, to others the slate uppermost, while to still another there seemed to be two beds of conglomerate. For years it was agreed that the felsite, porphory and diorite were all originally sediments changed to their present conditions by varying degrees of metamorphism.

In age the sedimentary rocks were variously classified, Cambrian, Devonion or Carboniferous.

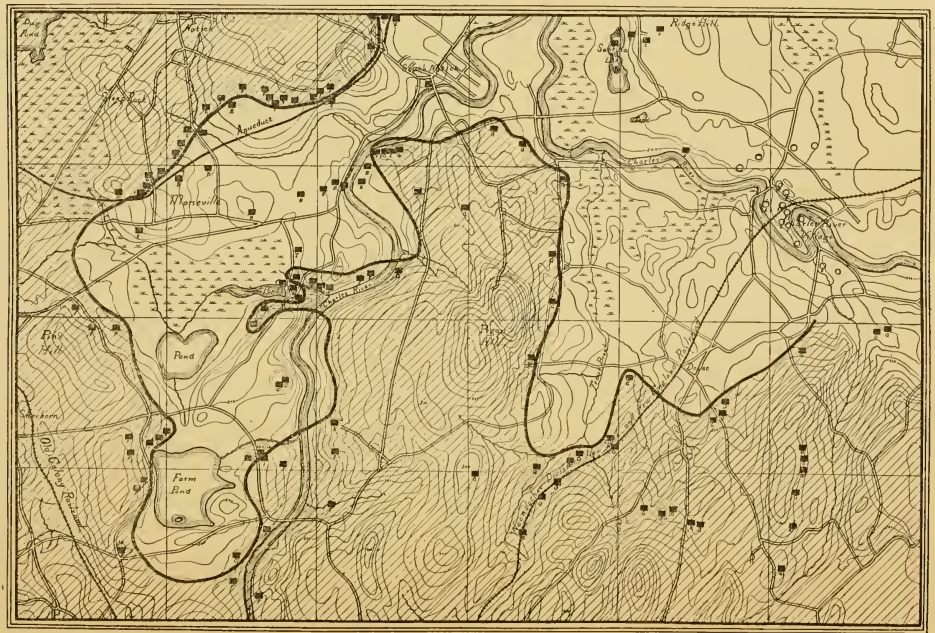
Since 1877, Dr. M. E. Wadsworth and Mr. J. S. Diller have given careful attention to these problems. In conclusion Mr. Diller,† after a presentation of evidence that seems incontro-

*The discussion is given in full in "The Azoic System," Whitney and Wadsworth, Bull. Mus. Comp. Zool. at Cambridge, Mass., Vol. VII.

† "Felsites and their Associated Rocks north of Boston," J. S. Diller, Bull. Mus. Comp. Zool. at Cambridge, Mass., Vol. VII.

THE SOUTHWESTERN PART OF THE BOSTON BASIN.

J.L.Tilton, December, 1894.



vertible, based as it is on both detailed field evidence and microscopic examination of the rocks, states that in the area he studied the stratified rocks within the basin are the oldest rocks, the granites surrounding the basin are next in age, then come the diorite, diabase and melaphyre in order. He also concludes that the granites, felsites, diorite, diabase and melaphyre are all eruptive rocks, not derived by metamorphism from any part of the stratified rocks.

These conclusions relate to the part of the basin north of Boston where evidence is most abundant and complete. In the fall of 1894, it was the writer's privilege to study the southwestern part of this basin and to prepare the accompanying map, the plate of which is now kindly loaned by the Boston Society of Natural History. This map and the paper that originally accompanied it* give the location of outcrops to be found in the area under consideration and a discussion of the relation of those outcrops based in part on the field evidence and in part on the microscopical character of the rock. The basin itself was found to extend in narrow areas farther southwest than formerly supposed.

* "On the Southwestern Part of the Boston Basin," Proc. Boston Soc. Nat. Hist. Vol. XXVI, June 28, 1895.

NOTE ON THE NATURE OF CONE-IN-CONE.

BY CHARLES R. KEYES.

Cone-in-cone is a term which has been applied more or less widely to a peculiar structure often found in beds of shale. Ordinarily it appears in thin sheets or layers, from three to six inches in thickness. The bands have a more or less well-marked columnar structure, each column being about half an inch in diameter and composed of a series of small conical segments set one within another. In general appearance fragments resemble the familiar coral Lithostrotion.

Much has been written on the origin of cone-in-cone, and numerous and widely different explanations have been offered. So far as I know, none of these numberless attempts to account for this peculiar structure appear to be satisfactory expositions of the true cause of the formation.

Recently there have been obtained in Marion, Boone and Webster counties, in this state, some unusually instructive examples which offer, I believe, a correct solution to the problem of origin. These specimens range from a black, opaque, clayey variety—the common form—through all gradations to a white, translucent kind. The latter is found to be made up of numerous long, often needle-like crystals and flat plates which radiate from a center—the apex of the cone—new needles coming in as rapidly as the spaces between those near the center become large enough to admit them. Chemical analysis shows that this variety is nearly pure calcic carbonate, in a well crystalized form. Analysis of the more earthy kinds also show a high percentage of lime. The results of examinations by Prof. G. E. Patrick are as follows:

I. Clear variety from Madrid..... .....96.36 per cent $CaCO_3$
II. Clayey variety from Fort Dodge..... .....83.12 per cent $CaCO_3$

As the clear cone-in-cone acquires more and more clayey matter the crystals of calcite gradually lose their mineralogical

characteristics until in the common form the presence of calcite would not be suspected, and the surface of the cones, instead of showing clearly the individual calcite needles sharply terminating, has only a peculiar crinkled or roughened appearance.

Owing to the very strong crystalizing force known to be possessed by calcite, so powerful an influence is exerted by this substance in solution, which is manifestly at the point of saturation, though distributed rather sparingly through the clay layers, that even the clay is pressed into the form assumed under normal conditions by the calcite. The process and results are not unlike those which have taken place in certain sandstone beds in central France, in which calcic carbonate has crystalized in the sand, and large perfect models of sand cemented by lime are found, having the well formed and characteristic crystalographic faces of calcite.

TWO REMARKABLE CEPHALOPODS FROM THE UPPER PALEOZOIC.

BY CHARLES R. KEYES.

There have been recently discovered in the coal measures of Mississippi basin some excellently preserved remains of Cephalopods, which are remarkable on account of the huge size attained. Both are representatives of the retrosiphonate Nautoidea; but one is a member of the most closely coiled end of the series, while the other is a perfectly straight form. The former belongs to the genus Nautilus and the latter to Orthoceras.

The first group comprises a series of shells, which were obtained from the upper coal measures at Kansas City, Mo. Several unusually fine specimens are the property of M. S. J. Hare of that place, and others are in the possession of other collectors. The form was originally described by White* as *Nautilus ponderosus*, the diagnosis of which is essentially as follows:

* U. S. Geol. Sur., Nebraska, p. 236, 1872.

Shell attaining a large size, subdiscoidal; umbilicus large, or nearly equaling the dorse-ventral diameter of the outer volution near the aperture; volutions three, enlarging their diameter more than three-fold each turn; all broader transversely than dorse-ventrally; inner ones slightly embracing, while the last one is apparently merely in contact with the others near the aperture; each broadly flattened or a little concave on the periphery, and (particularly the last one) somewhat flattened between the periphery and the middle of each side, from which point the sides are broadly rounded into the umbilicus, the greatest transverse diameter being near the middle; ventro-lateral or outer angles of the last whorl (in somewhat worn casts), each provided with obscure traces of about twenty wide, undefined nodes, scarcely perceptible to the eye; septa numerous, rather closely arranged, making a slight backward curve on each side, particularly between the middle and outer angles and crossing the broadly flattened dorsum with a strong backward curve; surface with distinct lines of growth, which curve strongly backward like the septa, in crossing the outer side.

White's specimen was not as perfect; the recently acquired material, and consequently the latter, is of unusual interest as elucidating structural points which were previously obscure. The large dimensions which the shell attained is quite remarkable, especially when taken in comparison with the other forms of the group known from the same geological formation. Rarely do any of the species of the genus from the Carboniferous of the region reach a diametric measurement of more than four or five inches. The specimens of *Nautilus ponderosus* recently found are twelve to fifteen inches in diameter and weigh upwards of fifty pounds.

The second group to which attention is called includes a huge Orthoceras—*O. fanslerensis*—from the lower coal measures at Fansler, Guthrie county, Iowa. It may be briefly described as follows:

Shell very large, thin, tapering very gradually; septa very thin, moderately concave, about two to the space of an inch near the large end; surface smooth. Diameter at larger extremity three inches, length probably not less than six feet.

It is a well known fact that the straight-shelled cephalopod was an abundant form of life during Paleozoic times. This is attested by the large number of species that have been described, those of the Orthoceras group alone numbering over 1,200. The culmination and greatest expansion of the group was in the Silurian, and from that period it appears to have gradually dwindled in number of species, size and abundance until at the close of the Paleozoic the form was all but extinct. In the American Silu-

rian some of the shells attained huge proportions, but with the general decline of the group the later ones have heretofore seemed to rapidly become dwarfed until only small, unimportant individuals were recorded after the Devonian. In the Carboniferous a few dimunitive species have been described, most of them but a few inches in length. In the coal measures of the Mississippi basin the remains found were of rather rare occur-

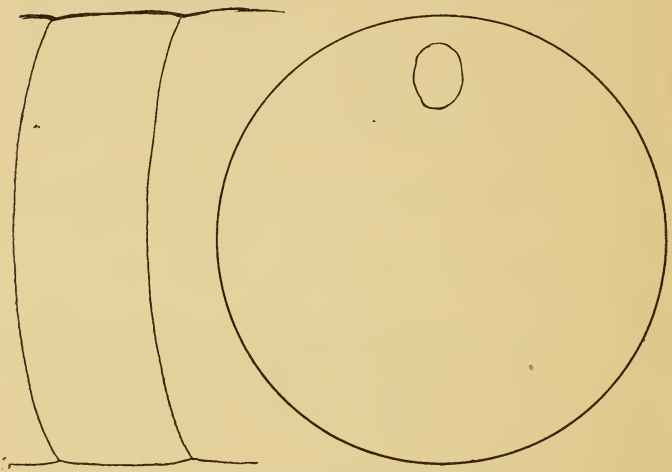


FIGURE 4. Section of Orthoceras fanslerensis.

rence, imperfectly preserved and of very small size. Seldom did the shells exceed six inches in length and half an inch in diameter.

Of late years, however, some unusually fine material has been obtained in the black shales of the lower coal measures in the vicinity of Des Moines, Iowa. Several of these shells were so large as to excite considerable wonderment. Some were over two feet long and one inch in diameter at the larger end. These were thought to be giants of their kind and day. But these are small, and all the other Carboniferous species are mere pigmies by the side of the recently found shell from the coal mines of Fansler. The species is *O. fanslerensis*, and the unique specimen here described was obtained by Mr. M. G. Thomas, state mine inspector.

VARIATION IN THE POSITION OF THE NODES ON THE AXIAL SEGMENTS OF PYGIDIUM OF A SPECIES OF ENCRINURUS.

BY WILLIAM HARMON NORTON.

In defining the different species of the genus encrinurus (Emmrich) use has frequently been made of the disposition of nodes on the rings of the mid-lobe of the tail-shield. It is largely by this diagnostic that Foerste, for example, distinguishes *E. thresheri* from *E. ornatus*. Hall and Whitfield* and the latter authors again, use the same criterion in separating *E. ornatus* from the European species figured in Murchison's Siluria.†

This has been the perhaps unavoidable result of the scarcity of materials at hand. Several species of this genus have been described, each from a single pygidium. The specific importance of this feature having thus been exaggerated, any variation in it is of paleontological as well as evolutional interest, and will be of value in the long-needed revision of the genus.

The specimens which afford the facts I am about to present were taken some years since by Prof. A. Collins, Sc.P , of Cornell College, and the author, from a single stratum near the top of Platner & Kirby's quarry, Mount Vernon, Iowa. They were associated with a rich fauna, but unfortunately the fossiliferous area was so limited that, though the quarry has been largely extended, scarcely a fossil has since rewarded the search of the collector. The investigation is therefore simplified by the absence of such factors as would obtain if the specimens had been taken from widely separated localities, or from a considerable vertical range.

Coming from a station near the summit of the Anamosa beds, which lie above the Le Claire, the position of the species is perhaps higher than that of any other American Encrinurus.

* The Clinton Group of Ohio, Part II, pp. 101, 102, A. E. Foerste. Bulletin of The Laboratories of Denison University, II.

† Report Geological Survey of Ohio. Vol. II, pp. 155, 156.

The species in question which is of the general type of *Encrinurus punctatus* Wahlenburg, is well represented in the collections by two perfect, or nearly perfect, specimens and by scores of cephelons, moveable cheeks and pygidia, occurring both as external moulds and internal casts.

The nearness of the fossiliferous stratum to the top of the quarry brought it well within the zone of weathering. The laminæ of the rock were parted and the fossils thus disengaged with a single stroke of the hammer, and without any picking and cleaning that might mingle artificial with the delicate natural markings. The latter are exceptionally well preserved. To speak of the pygidia only, the caudal spine is shown in several specimens, the ninth pair of pleural are usually distinct, and even a tenth pair may sometimes be seen as minute ridges nearly aligned with the axial lobe and ending upon it in a tubercle. Of the segmental lines on the mid-lobe as many as thirty-one have been counted with the aid of a magnifying glass, and in seven specimens over ,twenty-five are thus visible, and in several specimens eight and even nine axial nodes have been observed.

The investigation has thus been specially favored in the number and perfection of the specimens at hand. The prominence also of the large rounded anterior tubercle affords a sure ground which would be lacking if the investigation were carried over to the less distinct tubercles on the broad pleural annulations. In the same way the size of the specimens is of advantage. The largest twenty-three mm. in length and width, slightly exceeds in these dimensions the largest Encrinurus the author has seen figured or described. From this size the specimens range to a minimum of eight mm. in length and breadth. In several of the smaller pygidia, the axial lobe is slightly more convex and the central longitudinal space between the discontinuous segments is more or less obscure. The first nine segments in especial, are plainly continuous. While it is not thought that these are specifically distinct, they are separated in the following table by being marked with a star. Excluding these and considering the remainder whose specific identity can not be questioned, the following variation is observed:

No. of Nodes.	AXIAL SEGMENTS OCCUPIED.
1.	1st. 2d. (?) 3d.
2.	3d. 4th. 5th. 6th.
3.	7th. 8th. 9th. 10th.
4.	10th. 11th. 12th. 13th. 14th.
5.	14th. 15th. 16th 17th. 18th. (?) 19th.

The following table sets forth the facts observed graphically and in detail. It will be noted that not a single segmental line of the first twenty-three is unoccupied by a tubercle. No law obtains as to the successive number of the intervening segments. For comparison the sequences of nodes on two described species are inserted. Of the distinct trends observable in the grouping of the nodes that toward the formula of *E. ornatus* is most largely represented in the specimens at hand.

Geological Laboratory, Cornell College, December 31, 1895.

NUMBER OF AXIAL ANNULATIONS.

NO. OF SPECIMEN.	NUMBER OF AXIAL ANNULATIONS.																								
	1st.	2d.	3d.	4th	5th.	6th.	7th.	8th.	9th	10th	11th	12th	13th.	14th.	15th.	16th.	17th	18th	19th.	20th.	21st.	22d.	23d.	24th.	25th.
1	..	..	..	..	0	..	..	..	0	..	..	..	0	..	..	..	0	..	..	..	..	..	..	..	..
2	..	0	..	..	0	..	..	..	0	..	..	..	0	..	..	..	..	..	0	..	..	..	..	..	..
3	..	0	..	..	0	..	..	..	0	..	..	..	0	..	..	..	0	..	..	..	..	..	..	..	..
4	..	0	..	..	0	..	..	0	0	..	..	..	0	..	..	0	..	..	..	..	..	0	..	..	..
5	..	0	..	..	0	..	..	0	..	..	..	..	..	0	..	..	0	..	..	..	..	..	..	..	..
6	..	0	..	..	0	..	..	0	..	..	..	..	0	..	..	..	..	..	..	..	..	..	..	..	..
7	..	0	..	..	0	..	..	0	..	..	..	..	0	..	..	..	..	..	..	..	..	..	..	..	..
8	..	0	..	..	0	..	..	0	..	..	0	..	..	..	..	0	..	..	0	..	..	..	..	..	..
9	..	0	..	..	0	..	..	0	..	..	..	..	..	..	..	..	..	0	..	..	..	..	..	..	..
10	..	0	..	..	0	..	..	..	0	..	..	..	..	..	0	..	..	..	..	..	..	..	..	..	..
11	..	0	..	..	0	..	..	..	0	..	..	..	0	..	..	..	..	0	..	..	..	..	..	..	..
12	..	0	..	..	0	..	..	..	..	..	..	0	..	..	..	0	..	..	..	..	0	..	..	..	..
13	..	0	..	..	0	..	..	0	..	..	..	0	..	..	..	0	..	..	0	..	..	..	..	..	..
14	..	0	..	..	0	..	..	0	..	0	..	..	..	..	..	0	..	..	..	..	..	..	..	..	..
15	..	0	..	..	0	..	..	0	..	..	0	..	..	..	..	0	..	..	..	..	..	..	..	..	..
16	..	..	..	..	0	..	..	..	0	..	..	..	0	..	..	..	0	..	..	..	..	..	..	..	..
*17	..	0	..	..	0	..	..	..	0	..	..	..	0	..	..	0	..	..	..	..	..	..	..	..	..
18	..	0	..	..	0	..	..	..	0	..	..	0	..	..	..	..	..	..	..	..	..	..	..	..	..
19	..	..	..	..	0	..	..	..	0	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
20	..	0	..	..	..	0	..	..	..	0	..	..	0	..	..	..	0	..	..	0	..	..	0	..	..
21	..	0	..	..	..	0	..	..	..	0	..	..	0	..	..	..	0	..	0	..	..	..	0	..	..
22	..	0	..	..	..	0	..	..	0	..	..	..	0	..	..	..	..	..	0	..	..	..	..	..	..
23	..	0	..	..	0	..	..	..	..	0	..	..	0	..	..	0	..	..	..	..	..	0	..	..	..
24	..	0	..	0	..	..	0	..	..	..	0	..	..	..	..	0	..	..	..	..	..	..	..	..	..
25	..	..	..	0	..	..	..	0	..	..	..	0	..	..	..	..	0	..	..	..	..	..	..	..	..
†26	..	0	..	0	..	..	0	..	..	0	..	..	0	..	..	0	..	0	..	..	..	..	..	..	..
27	..	..	..	0	..	..	0	..	..	..	0	..	..	..	..	..	0	..	..	0	..	..	..	..	..
28	..	..	..	0	..	..	0	..	..	0	..	..	..	..	..	0	..	..	..	..	..	..	..	..	..
29	..	..	..	0	..	..	..	..	..	0	..	..	..	..	..	..	0	..	..	0	0	..	..	..	..
30	0	..	..	0	..	..	..	..	..	..	0	..	..	..	..	..	0	..	..	..	..	..	..	..	..
‡31	0	..	..	0	..	..	0	..	..	0	..	..	0	..	..	0	..	0	..	..	..	..	..	..	..
32	..	..	..	0	..	..	0	..	..	0	..	..	0	..	..	..	0	..	..	0	..	..	0	..	..
33	..	..	..	0	..	..	0	..	..	0	..	..	0	..	..	0	..	..	..	0	..	..	..	..	..
34	..	..	0	..	..	0	..	..	..	0	..	..	0	..	..	..	..	..	..	..	..	..	..	..	..
35	?	..	0	..	..	0	..	..	0	..	..	0	..	..	..	0	..	..	..	..	..	..	..	..	..
36	0	..	0	..	..	..	0	..	..	0	..	..	0	..	..	..	0	..	..	..	..	..	..	..	..
37	..	..	0	..	..	0	..	..	0	..	..	0	..	..	..	0	..	0	..	..	..	..	..	..	..
38	..	..	..	..	..	..	..	0	..	..	0	..	..	..	..	..	0	..	..	..	..	..	..	..	..
39	..	..	..	..	..	0	..	..	..	0	..	..	0	..	..	0	..	..	0	..	..	..	0	..	..
40	..	..	..	..	0	0	..	..	..	..	..	..	..	0	..	..	0	..	..	..	..	..	..	..	..
41	..	..	..	..	..	..	0	..	..	0	..	..	0	..	..	0	..	..	..	..	..	..	..	..	..
42	..	..	..	0	..	..	0	..	..	..	..	0	..	..	..	..	0	..	..	..	..	..	..	..	..
43	..	..	..	..	..	0	..	..	0	..	..	0	..	..	..	..	0	..	..	..	..	..	..	..	..

*No. 17. *E. ornatus*, H. & W. †No. 26. *E. punctatus*, Murch S.luria. Pl. III, fig. 6
‡No. 31. *E. threshei*, Foerste.

A THEORY OF THE LOESS.

B. SHIMEK.

Some years ago in an article entitled "The Loess and Its Fossils,"[1] the writer advanced certain opinions the modification of which seems to be called for by subsequent investigation and thought.

In that paper it was shown, principally from a study of the fossils, that the theory of the lacustrine origin of the loess, held with very few exceptions by American writers,[2] is untenable, and that the origin of the loess in violent fluviatile floods, also sometimes suggested, is equally improbable, and the theory was there offered that the deposit was formed in ponds and lakes similar to those which were formerly abundant in northern Iowa, and by quiet overflows of the sluggish prairie streams.

Although it is extremely probable that certain limited portions of the unmodified loess were deposited in this manner, the theory does not account for the most extensive deposits which usually cap the highest hills, especially along our streams which so often seem to cut their channels through the highest ridges. This difficulty led the writer to further investigation, which led to the conclusion that wind was the prime agency concerned in the formation of these deposits, and that Richthofen's theory of the formation of the Chinese loess, tempered and modified in important particulars, will account for all the phenomena of the loess of the Mississippi valley.

That the loess is not of aquatic origin is indicated by the following facts:

[1] *Bull. Nat. Hist. S. U. I.*, Vol. II, pp. 93-98.

[2] Prof. Calvin, in *Iowa Geol. Survey*, Vol. IV, p. 84, recently suggested the aeolian origin of a part of the loess in Allamakee county.

First.—The land area during the period of the formation of the loess was large as is shown by the remains of great numbers of terrestrial molluscs.[3]

Not only the number of species but the number of individuals of the terrestrial forms is much greater, a fact especially significant since the pond molluscs are all very prolific and had the conditions been favorable to their development much greater numbers of the fossils should occur.

That the shells of the loess were deposited *in situ* and were not carried any great distance by water has already been pointed out by the writer.[4]

Second.—The occurrence of dry region molluscs, such as *Succinea lineata*, *Pupa atticola*, *Patula cooperi*, etc., has also been pointed out.[5] The great majority of the remaining species occur now in a living state throughout Iowa and eastern Nebraska, more particularly in wooded regions. Most of them do not seem to require an excess of moisture, but thrive under present conditions.

Third.—The deposits often occur so high above the surrounding region that it is difficult to conceive of the manner in which water laden with the fine silt could reach the places of deposition.

Fourth.—The siliceous and other particles which the loess contains are generally angular and often show a freshness of fractures which would scarcely appear in particles which had been rolled and washed about by the waters.[6]

Fifth.—The distribution of the loess is better accounted for by the consideration of the action of winds, and by the distribution of the forest areas, as will be shown in the following pages.

The fact that stratification and lamination sometimes appear in the loess, showing the action of water, together with the presence of aquatic molluscs, can also be accounted for under the wind theory; for, as now, so at the time that the deposits were being formed, ponds and lakes of various sizes were scattered over the state, and much of the dust carried out in clouds over these bodies of water would have been deposited in them.

[3]See *Bull. Nat. Hist. State Univ. Iowa*, Vol. I. p. 209, *et seq. Succinea verilli* and *Pupa decora* should be stricken from the list, and *Pupa holzingeri* Sterki should be added. This species is rather rare in the loess of Nebraska, but in the living state it is quite common in both Iowa and eastern Nebraska.

[4]*Bull. Nat. Hist. S. U. I.* Vol. II. pp. 95 and 96.

[5]*Ibid.* p. 93.

[6]See also Prof. R. D. Salisbury's report in *Ark. Geol. Survey*, Vol. II. pp. 225, 226.

That such bodies of water existed, though, as before stated, not of the extent required by the lacustrine theory, is also shown by the distribution of the pond mollusca, which are found in bands or layers similar to those which may be observed on the edges of our small ponds to-day. These layers are usually of but slight vertical extent, showing that the ponds did not persist during the entire period of deposition of the loess, but, like the ponds of to-day, were subject to changes. But if the water area was not great, comparatively little of the material carried by the winds could be deposited in this manner, and as a matter of fact we find comparatively little loess which shows such origin.

Secondary loess, which had been subsequently eroded and re-deposited on lower lands by running waters, and which usually shows stratification, should not, of course, be considered in this conection.

In the consideration of any theory of the mode of deposition of the loess, two propositions, which seem to be capable of satisfactory demonstration, should be borne in mind, namely, that the loess was deposited under climatic conditions essentially the same as those which prevail in the same region to-day; and that the deposition was slow and continued through a period of considerable extent.

That the first of these propositions is true is shown by the molluscs which furnish the most satisfactory evidence of the character of the conditions supporting life during that period. The same species, with but very few exceptions, which occur in the loess, exist in abundance now throughout the region under consideration, the distribution of the fossils being exactly such as may be observed under present conditions. If, for instance, we compare the modern molluscan fauna of eastern Iowa with that of eastern Nebraska, we find certain differences which are almost exactly duplicated in the loess faunas of the two regions.[7]

For instance, *Succinea lineata* W. G. B., the common succinea of eastern Nebraska, is also the most common succinea of the loess of that region, whereas *Succinea avara* Say, the most common succinea of eastern Iowa, is also the most common species of the genus in the loess of the same region.

The majority of our species show a like distribution,[8] plainly

[7] No reference is here made to the Lamellibranch and Prosobranch fluviatile faunas, which seem to have spread into the region in question from their center of distribution in the southeast comparatively recently.

[8] The loess fossils of Europe are likewise like the modern forms inhabiting the same region.

indicating conditions not essentially different from those which now prevail.[9]

Additional weight attaches to the evidence of these molluscs when we consider that they are in themselves witnesses to an abundant flora of the period, for with scarcely an exception they are purely herbivorous, and frequent places in which shade, protection and food are furnished by abundant plants.

The presence of a vigorous vegetation is further attested by the leaching of peroxide of iron from the loess soil and its deposition in tubules and concretions.[10]

That the amount of moisture was not excessive has already been pointed out. The great preponderance of terrestrial molluscs, at least some of them, now capable of living and multiplying in regions even drier than that under consideration, and the majority of them living abundantly in our state to-day, is certainly significant.

But even if we grant that the average temperature was somewhat lower than at present, and the amount of moisture somewhat greater—conditions by no means essential to the phenomena of the loess—it cannot be questioned that the climate of the loess was sufficiently mild to support an abundant fauna and flora from the very beginning of the formation of these deposits. Glacial conditions certainly no longer existed, for sufficient time must have elapsed after the recession of the glaciers to clothe these prairies with verdure, for the mollusc remains are found in the lowermost portions of the deposits and the favorable conditions necessary for their development must have existed from the very beginning. The prevailing conditions being then essentially the same as now, and the topography of the continent being essential as we find it to-day, it seems fair to assume that the prevailing strong winds were, as now, northwesterly. This point will again be emphasized.

The truth of the second proposition that the loess was deposited slowly is supported by the following facts:

[9] The writer formerly leaned toward the conclusion, drawn by McGee and Call in a paper on the loess of Des Moines, that the occurrence of depauperate forms was proof of a much colder climate than now prevails, but he has since found recent forms of several of the species common in the loess which exhibit great variation under different conditions even in the same locality. For example, shells of living *Mesodon multilineata* Say, from different points in the immediate vicinity of Iowa City, vary from 15 to 26 mm. in greater diameter, while fossils of the same species from the same region now in the writer's possession vary from 12 to 23 mm. This variation seems to be purely local and cannot be assigned to general climatic conditions. This was suggested in the writer's paper to which reference has already been made, p. 93, footnote 2.

[10] See *Le Conte's Geology* pp. 136, 137

First.—The vertical distribution of the molluscs. The writer has already shown[11] that these molluscs were most probably deposited *in situ*, and sufficient time must have elapsed at least for the production and developement of the successive generations.

Second.—The fineness and homogenity of the loess material. This is of importance, for had the deposits been made quickly by powerful concentrated agencies, whether wind or water, much more coarse material would have been mingled with the fine debris.

Third.—No plant remains of undoubted loess origin occur. As the plants undoubtedly existed during the entire period the deposition must have gone on so slowly that ample time was given the plant remains to crumble in decay and mingle with the soil.

With these propositions as an aid let us consider the following conception of the formation of the loess deposits:

The region formerly covered by the glaciers remained a vast drift-covered plain after the recession of the glaciers.

No loess was to be found, but the surface material consisted of unassorted drift, here and there heaped up in ridges and moraines. Streams soon cut their way through this material[12] and ponds more or less numerous remained in the depressions of the plain.

The climatic conditions having so improved, plants, at first the smaller forms, spread over the plain, and soon trees, in whose shades numerous molluscs lived and prospered, appeared in narrow lines along the streams, the surface conditions being not unlike those of the northwestern portions of the state to-day. Forests gradually spread over portions of the area, principally along the river-valleys and on hillsides in the manner pointed out by Prof. Macbride.[13]

When vegetation, especially the forests, had gained a foothold, then commenced the deposition of the loess.

[11] *Bull Nat. Hist. S. U. I.*, Vol. II, p. 95.

[12] If it be true that our streams generally follow the highest ridges of the drift, even without reference to the loess, i. e. if the streams run in *glacial* ridges (and the writer knows of some cases where this is true), then the fact can be accounted for by the theory offered in the paper by McGee and Call already cited, pp. 22-23, but the theory fails when applied to the loess because of the climatic conditions required.

[13] See paper: *Forest Distribution in Iowa and its Significance, in this volume.*

It is but fair to say that the theories thus presented by Professor Macbride and the writer, while leading to the same results, were developed from different standpoints along entirely independent lines of investigation.

The strong northwesterly winds blowing over the prairies, which during a part of the year at least were quite dry, gathered up clouds of sand and dust. The coarser material was blown and rolled about on the surface, the constant grinding furnishing renewed supplies of finer material, while this finer material was carried higher, being finally swept over the forests, and there deposited.[14]

That this is not a fanciful view of the work actually performed by winds has been nicely demonstrated in eastern Iowa during the past two years. High winds prevailed during considerable portions of both years, the dry spring of 1895 being particularly remarkable in this respect, and observations upon the material so transported were made in Johnson county. In the northern prairie portion of the county, beyond Solon, fine sand was heaped up in open places, in some cases to a depth of over a foot, within twenty-four hours, while fine dust only was carried into adjacent groves, and was there deposited upon every available surface to a depth of not less than one mm. The writer's observations of the effect of the winds which so prevail in Nebraska also confirm this.

That this fine material now constituting the loess, was so deposited in forests is further shown by its distribution. That the loess and the original forest area in eastern Iowa almost exactly coincide is a well established fact, which has been demonstrated beyond question by McGee.[15]

The forests are found along the streams, and also principally on the southern and eastern slopes of the hills, and the loess is found in exactly the same situations.

Indeed it has often been suggested that there is something peculiar to the loess which renders it favorable to the development of the forests—whereas the fact seems to be that the forest is especially favorable to the deposition of the loess if lying adjacent to or near drift-covered plains.

That the forest could have preceded the loess is shown by the fact that scrub growths of bur oaks have been able to gain a foothold along the shores of some of our northern (Iowa) lakes and streams in a purely glacial soil, thus forming the nucleus of a forest in comparatively recent time, while in the same region in groves evidently somewhat older a thin layer

[14] Interesting observations were made in 1894 by F. H. King (see *Eleventh An Rep of the Wisconsin Agr. Ex. Sta.*, p. 292 *et seq.*) upon the effect of winds on vegetation in drifting soil which bear out the conclusions presented in this paper.

[15] U. S. Geol. Sur., 11th Ann. Rep., Part I, pp. 296, et seq.

only of loess-like soil is found.[16] Quite important too is the argument furnished by the physical properties of the loess material. This in eastern Iowa is always very easily eroded, so much so that upon cleared hillsides it is often impossible even for bluegrass to gain a foothold, and failure has been the universal result of all attempts to cultivate such slopes. This being the case it seems hardly probable that trees, which require more time to become established than do smaller plants, could have gained a foothold upon these unstable hilltops had they been formed. The organic matter which undoubtedly accumulated in these forests gradually decayed, mingled with the alluvium brought by the winds, and was finally consumed in leaching iron oxides from the lower strata of deposit.

Other, smaller, vegetation no doubt effected the deposition of fine alluvium in the same manner, but to a lesser degree, and by the aid of this probably were formed the thin layers of loess which sometimes occur in prairie country.

The element of time still remains to be considered. Without an attempt at exact computations, attention is simply called to the fact that in eastern Iowa the loess in no place exceeds fifty feet in thickness, the average being probably about ten or twelve feet, and that if we assume, for example, the deposition of a minimum of one mm. a year, the time required for the formation of the entire deposit would not be unreasonably great.

The deposition of loess material is no doubt going on in this manner to-day, and the investigation of this phase of the subject is worthy the attention of the most careful observers. The foregoing statements apply particularly to the loess of eastern Iowa. In the western part of the state and in eastern Nebraska much thicker deposits occur, which differ in many respects from the loess of eastern Iowa.

The western loess is thicker, coarser, with more siliceous material, and the writer has found it more frequently interlaminated with sand. That it is much less easily eroded because of this difference in composition is a well known fact.

From the general topographical and climatic relations which exist between the eastern and western regions to-day, it is probable that during the loess period, as now, the western region was drier (a fact also attested by the rather greater abundance of dry-region molluscs in its loess), and that strong winds were

[16]A further investigation of the soils in prairie groves of this kind is contemplated during the coming summer.

of more frequent occurrence than in the eastern region. The stronger winds and drier climate would coöperate in effecting the transportation of larger quantities of alluvium, which would also be somewhat coarser and more siliceous. The frequent interlamination of sand with the loess can be accounted for by more violent storm-periods.

The writer has seen such alternating deposits of sand and loess in Cuming county, Nebraska, near the margin of the Sand Hill country, which clearly show wind-action.

Much could also be written of the changes which probably took place after the deposition of many of the beds of loess, of the denudation of some of the hills, the modifications of the deposits by erosion, and kindred subjects, the discussion of which in connection with this question would be legitimate and desirable, but this would extend this paper beyond reasonable limits, and is therefore postponed.

The consideration of the facts herein briefly presented leads, then, to the conclusion that the loess is of æolian origin, and that it was deposited principally in forests and to a lesser extent in dense growths of smaller plants, while proportionately small quantities only were carried directly into the waters and there deposited.

PERFECT FLOWERS OF SALIX AMYGDALOIDES ANDS.

B. SHIMEK.

A native specimen of *Salix amygdaloides* Ands. growing in Iowa City, produces peculiar flowers which seem to be worthy of mention.

Whereas all *Salicaceae* habitually produce dioecious flowers, this specimen has, for at least three successive seasons, borne flowers most of which are perfect.

The accompanying figures will give a clearer idea of these peculiar flowers.

The hairy bract is shown at the extreme left; next to this is the narrow dark honey-gland (there are really three such glands in line in each flower) here occupying an unusual position, as in willows the honey-gland is normally in the axil of the pedi-

cel, and not between it and the bract as in this case; next are the stamens, being three in number, in all the flowers which were examined, but varying in position, some being on the receptacle, and others on the ovary; to the extreme right is the peculiar pistil which, instead of having a one-celled ovary, with

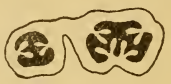


Fig. 1 Fig. 2.

FIGURE 5. *1* entire perfect flower; 2 cross-section of ovary.

two parietal placentae as in normal willows, usually has a two-celled ovary, one of the cells being nearly normal with two placentae, while the other is larger and shows four placentae, two of them consolidated, as shown in figure 2 which represents a cross-section of the ovary. These figures represent a fair average example of the perfect flowers, but considerable variation was observed. Some catkins consisted of staminate flowers wholly, being normal with five stamens. Other catkins had perfect flowers in part only, these being either apical, basal, or scattered, while still others had all the flowers perfect. A few pistillate flowers were also found.

The stamens in the perfect flowers vary much in length, all being shorter however than those of the truly staminate flowers, and they also show much variation in the development of the anthers, some being evidently abortive.

The perfect flowers produce seed, but whether this is capable of germination was not demonstrated.

COUNTY PARKS.

BY T. H. MACBRIDE.

The title of this paper would seem to require little definition. By county parks are meant simply open grounds available for public use in rural districts, as are city parks in towns. There is nothing new in the idea; it is simply an effort to call back into public favor the once familiar public "common." This does not, however, refer simply to public land such as government land, to be claimed and plundered by the first comer, nor, indeed, to land to be used by the public indiscriminately at all, but to land devoted to public enjoyment, purely to the public happiness, a holiday ground for country- and city-folk alike.

The general features which should characterize such public play-ground as is here discussed will also quickly suggest themselves to any one who chooses at all to consider the matter. In the first place the county park should be wooded, that it may afford suitable shade and shelter for those who frequent it; it should be well watered to meet other patent needs; it should be romantic, in order by its attractiveness to be as far as possible efficient. Above all it must be under wise control, be at all times suitably warded and kept, that its utility be transmitted from generation to generation. All this is plain enough and will be disputed by nobody. It is my purpose here to show that such parks are needed, that they are needed now, that they should have the highest scientific value, and that in Iowa they are everywhere practicable.

The necessity for such parks in Iowa seems to me to be threefold:

First.—As directly affecting public health and happiness.

Second.—For proper education.

Third.—To preserve to other times and men something of primeval nature.

Let us consider these points briefly in the order named

All of us in one way or another know something of the monotonous grind which makes up the life-long experience of by far the larger number of our fellow men. On the farm, in the shop, in the mine, day after day, one unceasing round of toil, into which the idea of pleasure or freshness never enters. How many thousands of our fellow men, tens of thousands of our women see nothing but the revolving steps of labor's tread-mill, day in, day out, winter and summer, year after year, for the whole span of mortal life. This is especially so here, in these western states, where the highest ideal is industry, the highest accomplishment, speed. Our rural population is wearing itself out in an effort to wear out "labor-saving machinery." If you do not believe it take a journey across the country, anywhere through Iowa, and see how our people are actually living. They know no law but labor; their only recreation is their toil. Now, it is needless to say how abnormal all this is. We are as a people entrapped in our machines, and are by them ground to powder. The effect of it is apparent already in the public health, and will be the most startling factor in the tables studied by the man of science in the generations following. Not to paint too darkly the picture, attention may be called to the fact that rural suicides are not uncommon, and that the wives of farmers are a conspicuous element in the population of some of our public institutions. There must be something done to remedy all this, to preserve for our people their physical and mental health, and to this end, as all experience shows, there is nothing so good as direct contact with nature, the contemplation of her processes, the enjoyment of her peaceful splendor. If in every county, or even in every township, there were public grounds to which our people might resort in numbers during all the summer season, a great step would be taken, as it seems to me, for the perpetuation, not to say restoration, of the public health. We are proud to call ourselves the children of "hardy pioneers," but much of the hardiness of those pioneers was due to the fact that they spent much of their time, women, children and all, out of doors. All the land was a vast park, in which that first generation roamed and reveled. They breathed the air of the forest, they drank the water of springs, they ate the fruit of the hillsides while plum thickets were their orchards, and all accounts go to show that hardier, healthier or happier people never lived. Such conditions can never come again, but we may yet, by public grounds for common enjoyment, realize somewhat of the old advantage.

Again, such parks as are here discussed are an educational necessity. Our people as a whole suffer almost as much on the esthetic side of life as on that which is more strictly sanitary. How few of our land-owners, for instance, have any idea of groves or lawns as desirable features of their holdings. If in any community a farm occurs on which a few acres are given over to beauty the fact is a matter for comment for miles in either direction. A county park well-kept and cared for would be a perpetual object lesson to the whole community, would show how the rocky knoll or deep ravine on one's own eighty-acre farm, might be made attractive, until presently, instead of the angular maple groves with which our esthetic sense now vainly seeks appeasement, we should have a country rich in groves conformable to nature's rules of landscape gardening if not to nature's planting.

I am aware that at the first the right appreciation of a public park might be meagre. The first instinct might be to use the park as a convenient source whence to draw one's winter firewood, or as a free cow-pasture for the adjoining farmer, but such abuse would soon be rectified when the better idea of public ownership came to be understood. This leads also to the remark that such parks in Iowa are to-day absolutely needed to teach our people the first lessons in forestry; to advise them how and when to cut timber; the economic value of different kinds of trees and the value of woodland as such; the kind of soil which should be left to trees and such as may be profitably given over to tillage. We are soon as a people to be sent all to school in matters of forestry and arboriculture; sent to learn the value of the forest in the dear school of experience where we are to be taught the arithmetic of cost.

In the third place county parks would tend to preserve to those who come after us something of the primitive beauty of this part of the world, as such beauty stood revealed in its original flora. I esteem this from the standpoint of science, and, indeed, from the standpoint of intellectual progress, a matter of extreme importance. Who can estimate the intellectual stimulus the world receives by the effort made to appreciate and understand the varied wealth of nature's living forms? In this direction who can estimate how great has been our own advantage as occupants of this new world? But such is the aggressive energy of our people, such their ambition to use profitably every foot of virgin soil that, unless somewhere

public reserves be constituted, our so-called civilization will soon have obliterated forever our natural wealth and left us to the investigation of introduced species only. and these but few in number. It is a fact lamented, grievously lamented by all intelligent men, that in all the older portions of the country species of plants once common, to say nothing of animals, are now extinct County parks, if organized soon, would enable us to preserve many of these in the localities where originally found.

The objection to all this is that such parks as here broached are impracticable. Such objection can lie in two directions only: (1) The lack of suitable sites, and (2) the lack of suitable control. As to the first, it may be said that in a great number of our counties, especially eastward, such sites exist and have, in many cases, been long used and, I am sorry to say, abused by our people:

"The Caves," in Jackson county;

"The Backbone," in Delaware county;

"Wild Cat Den," in Muscatine county;

"Gray's Ford," in Cedar county;

"Pinney's Spring," in Allamakee county.

"The Palisades" in Cedar and Johnson counties, may be cited as illustrations both of the fact that sites exist and that people need and appreciate them. The "Backbone," in Delaware, is ideal. Here are cliffs and rocks, woods, rivers and bountiful springs and, what is rare in Iowa, clusters of native pine. Hundreds of people visit the locality every year, and hundreds more would do so were the roads leading to the park in more passable condition, and especially were the grounds a park properly managed and controlled instead of, as now, a cow pasture, so stocked as to jeopardize everything green it contains. The "Den" in Muscatine county might be referred to in the same way. I believe it is not yet too late to find in possibly three-fourths of our Iowa counties, suitable sites, grounds, for the purpose contemplated in this argument.

The second count in the way of objection is a real difficulty whose gravity I do not for a moment attempt to minimize. How to secure, own and care for several hundred, or for that matter, several thousand acres of land to be used by all the people is a problem, especially under our form of government. Were we in the old world we should find no difficulty. Such localities are owned by the king or his equivalent and are

cared for and guarded with the same assiduity as any other private property. Nevertheless the people have free use of the most splendid parks and beautiful woods in the world. The same thing can be true of the United States, of Iowa, hopeless as the task may now seem. In the eastern states a movement to this end is even now discernible.

What Mr. Vanderbilt is doing in North Carolina, at Biltmore, will doubtless be done presently in all our mountainous and forested states. This is another opportunity for our millonaires, and forest foundations properly established will prove for future generations rich in benediction as any university endowment left in the name of whatsoever state or sect. In Massachusetts five years since a movement was inaugurated for the accomplishment of similar purposes in New England. A board of trustees, by legislature authorized to act, becomes the legatee of suitable property donated for public use, becomes the curators of such grounds and the custodians of funds bequeathed for the care of such lands or for their purchase. The results in Massachusetts of just a simple effort have in five years proved most gratifying to the projectors, as to every lover of his native land. Thousands of acres have already been rescued from spoliation and subjected to intelligent management, such as will eventually result in the attainment of all the beneficent ends for which public parks exist. In Iowa nothing is done; nothing will be done until somebody or some association of our citizens makes a beginning. That the effort will one day be made there is no doubt. Whether it shall be made in time to save that which nature in this direction has already committed to our hands is a question. Is not the problem worthy the consideration of the Iowa citizen and legislator, and does it not open to us a field where by practical activity we may again show before the world our practical sense and wisdom?

NOTES ON FOREST DISTRIBUTION IN IOWA.

BY T. H. MACBRIDE.

The peculiar character of our American forest geography early attracted the attention of intelligent observers. Civilized men, Frenchmen, crossing the continent from the Atlantic seaboard, after threading for two hundred leagues a forest almost unbroken, suddenly found themselves in the presence of vast treeless plains, extending westward across a large portion of the central Mississippi valley. In wonder and admiration the *voyageur* looked upon these great plains, grass-grown and flower-bedecked, and found them counterpart to the green meadows of France; to them he gave the name prairie, a word now so familiar as to have long lost for all English-speaking men every vestige of foreign origin. How these great meadows ever came to exist or persist in the region where they first were seen, or why the forests of the east should so suddenly stop was a problem the *voyageur* could not solve, and has been a problem from the days of the *voyageur* until now.

In these times of almost universal forest extermination, when we are in sight of the era in which Americans must laboriously undertake the work of re-forestration, it is well that we should closely attend to conditions once established by nature, that we may hereafter act with her assistance, for in plant distribution, whatever our blunders may be or have been, nature we may be sure has seldom made a mistake.

In general, two factors are said to control forest distribution on the planet; the one, rainfall, the other, temperature. If the rainfall is deficient there can be no forest, rainfall seems never to be excessive, and if a region is too cold there is no forest. In proof of this we have but to look at the high altitudes and latitudes of the earth. What makes our Iowa problem therefore peculiar, is the fact that forest distribution here, as elsewhere in prairie regions, does not accord with these general

principles. Our country is not too cold, neither is it too dry; the rainfall in eastern Iowa being almost, if not quite as great as in Indiana, where the primeval forest was once heaviest. Indeed the uniformity of general conditions raises the problem: there seems to be nothing to hinder, therefore why is not the forest universal?

Various answers have been given to this question.[1]

The opinion first entertained and that which is generally still current among common people, was that the continental forests were limited by fires. The Indians started fires and these fires were slowly, at the advent of the white man, consuming the woods, had stripped large areas in the Mississippi valley and unchecked would eventually have reached the Atlantic coast. No one who has been an eye-witness of the conflagrations that once rolled in annual tides across Iowa or Illinois can doubt the force of the theory so long and so widely entertained. The difficulty lies in the fact that the forest stood the attack so well, in fact seemed largely unaffected, actually held its own in nearly every part of the fire-infested district. Then again, if the truth had been that the aborigines were destroying the woods at the time when the whites first became witnesses, proof of the fact should be found over the whole region in form of charred logs, stumps, etc., of which, needless to remark, there has been no trace whatever. The fire theory not wholly satisfactory, some students went to the other extreme and urged that the distribution of the woods was due to causes efficient in times remotely past, so that fires or present conditions had nothing at all to do with the matter; the solution of the problem must be sought in some earlier geologic age. Others again sought to solve the problem by *a priori* method. It was urged that trees exhaust the soil of one set of elements while grasses, herbaceous plants, demand something entirely different, so that either set of plants occupying for long ages a given region would exhaust its availability though leaving the ground serviceable for something else. Thus trees once occupied the whole Mississippi valley but had exhausted the ground of tree-material, so to speak, had worn out their welcome. The answer to this is that here in Iowa trees seem to grow everywhere if planted and cared for.

[1]See *inter al.* Am. Journal of Science VI, 384; XXXVIII, 332 and 344; XXXIX, 317; XL, 23 and 293. Geol. Survey of Illinois I, 238 *et seq*; Geology of Iowa, Hall, I. Part I, p. 23 *et seq*; U. S. Geol. Survey, Eleventh Annual Report of the Director, p. 236 *et seq.*

Prof. Lesquereux carries the idea of suitability of soil a little farther. He traces all prairies to old time lakes; declares that prairie soil is "neither peat nor humus, but a soft, black mould, impregnated with a large proporton of ulmic acid, produced by the slow decomposition, mostly under water, of aquatic plants, and thus partaking as much of the nature of peat as of that of true humus." * * * "It is easy to understand," he says, "why trees cannot grow on such kind of ground. The germination of seeds needs free oxygen for its development, and the trees, especially in their youth, absorb, by their roots, a great amount of air, and demand a solid point of attachment to fix themselves, etc." That is, the reason why our prairies are treeless is that they are too wet, and they contain, in virtue of their origin, certain elements to trees inimical. Professor Whitney also finds explanation of our prairies in the nature of the soil, "as the prime cause of the absence of forests and the predominance of grasses over this widely extended region. And although chemical composition may not be without influence in bringing about this result, * * * yet we conceive that the extreme fineness of the particles of which the prairie soil is composed is probably the principal reason why it is better adapted to the growth of its peculiar vegetation than to the development of forests."

Whitney makes also another very suggestive statement, the importance of which he did not himself realize. He says: "Wherever there has been a variation from the usual conditions of soil on the prairie or in the river bottom there is a corresponding change in the character of the vegetation. Thus on the prairie we sometimes meet with ridges of coarse material, apparently *deposits of drift*, on which from some local cause there has never been an accumulation of fine sediment; in such localities we invariably find a growth of timber. This is the origin of the groves scattered over the prairies for whose isolated circumstances and peculiarities of growth, we are unable to account in any other way."

It is interesting to notice the emphasis which Whitney here places on the character of this soil. No doubt there is something about prairie soils which makes them different from all other soils with which we are acquainted, and no doubt difference in soils is responsible for the difference in the forms of vegetation which they carry, but while both these excellent students, Lesquereux and Whitney, came in their surmises

very near the truth each of them in his theory missed the mark. It remained for an almost lifelong resident of the prairie, a former active member of this academy, to study to better purpose, Iowa's forest distribution, when, as a vigorous geologist he made his now famous pilgrimage through our eastern counties. Mr. McGee was quick enough to notice that the soils of our prairie region are indeed peculiar, and of several sorts, and that the vegetation varies with the soil, but he went farther: he referred the whole problem back to conditions geological, to a situation resultant from the nature and manner of the latest geological deposit. The soils of Iowa are three, the drift of the prairie, the loess of the hills, the alluvium of the river flood-plains, and Mr. McGee's contribution to our problem lies in his emphasizing the fact first noticed by Whitney, that the forests and groves of Iowa, except where alluvial, are everywhere coterminous with the distribution of the loess. Since Mr. McGee has called attention to the fact, of course, everybody sees it. The merest tyro in such studies has but to drive across some eastern county of our state to see how very striking the relation is. Every hill is clay-capped, and every clay-capped ridge is covered with woods. Sometimes the clay is replaced by sand, but the woods cover the sand, as Whitney says, just the same.

There is one other fact, however, to which attention has not yet been called, which has a distinct bearing upon our problem and that is the fact that subsequent to the occupancy of the state by civilization the forest began slowly to enlarge. Many localities might be cited in proof of this statement. I have in mind one field of thirty acres in 1844 cultivated as a cornfield, now used year after year as a grove for Fourth of July celebrations. Then again, as Whitney remarked, trees grow on all the alluvial soils of Iowa, so that outside the fact of soil-difference, there must be still a factor operating to make the difference in soil efficient. That factor in my opinion is that already mentioned as of universal popular appreciation, namely, *fire*. Fires have prevailed on the continent not only for generations as man reckons the years, but for forest-generations for hundreds and hundreds of years. In the presence of fires forests endure only as they have some special defense. This may be found in one or both of two conditions: in a limited amount of surface-moisture or in lack of combustible material on the surface of the ground. The alluvium offers both conditions; the

loess the latter. That is, to be more explicit, the loess with its sand and clay is a soil for cereals so poor as to raise but a small crop of grass, hence to furnish for sweeping fire a small amount of fuel, hence giving rise to less destructive fires, in which young trees were not universally destroyed. The drift on the other hand produces enormous wealth of grass, burning in conflagration which no seedling trees can endure; hence on the drift there are no trees. The presence of trees on rocky soils is to be explained in the same way. River bottoms furnish a special case. Here in the first case the current formed soil is in the nature of a sand bar, made of the coarser elements met with by the eroding flood. On sand bars cottonwoods and willows start, but not grass. The soil after a little becomes richer it is true, by subsiding slime, but by this time the locality is become moister than all the surrounding region; in summer, being lower, receiving heavier dews; in winter catching and longer retaining a larger proportion of snow, all tending as check to sweeping fires.

In conclusion, we are therefore prepared to say that all the students of our problems have been right, though each presented but a partial truth. Those who affirmed the agency of fire were right, but they failed to notice the fire's selective operation or to explain it. Those who attributed forest distribution to differences in soil were also right, but they failed to show or see how or why such difference availed. Those who looked back to a former geologic age were also right, but such failed entirely to show what the influence was which geologic structure has upon the problem.

To sum up: (1) The immediate agent in the limitation and distribution of Iowa forests was fire. (2) The sweep of fire was determined by a modicum of moisture and by the presence of *fuel upon the ground.* (3) The drift being especially adapted to gramineous vegetation, furnished fuel in such amount as to prevent the development of tree-seedlings, while the loess, using the term in a broad sense, less suited to gramineous species, furnished less fuel, hence gave to tree seedlings on loess regions opportunity to rise. (4) Special localities, as swamps, alluvial flood-plains, etc., present special cases and require special explanations.

As a corollary we may remark: (1) That the drift-plains of the state offer greatest promise to the farmer who seeks the cereals as his principal product. The wooded regions should

be left to woods as to their appropriate crop. The loess clay will never enable its cultivator to compete with his more fortunate fellow-citizen who farms the drift, and the sooner the people of Iowa find it out the better. (2) It is likely that orchards and vineyards will thrive better on the loess than on the drift, as trees generally may be supposed to have been subject to similar discipline in all time and in all parts of the world.

THE NOMENCLATURE QUESTION AMONG THE SLIME-MOULDS.

BY T. H. MACBRIDE.

That a man's difficulties are often of his own creating is a fact patent in science as in other fields. The imperfections of our methods form ever increasing nets of complexity about the feet of our progress. No one feels this more keenly than the naturalist, especially he who would attempt to give more exact account of some limited group or series of animals or plants. No matter how carefully he may arrange his materials, no matter how industriously he may have worked out the various problems of structure and morphology, there comes at last to plague him, to hinder him, to mar his purpose and waste his time, the question of nomenclature; his specimens must be named. This ceremony, the christening, which ought to have been the simplest matter in the world, has really become, if not the most difficult, at least the most annoying and thankless portion of his task. Preposterous also as it may seem, it is precisely the oldest and most universally recognized of the forms with which he deals that are apt to give the most trouble. There has arisen a class of critics among us who have devoted their energies to the unsettling of scientific nomenclature in every department of research, with the result that, rightly or wrongly, every systematic work in the world needs revision if not re-writing, and every herbarium in the world needs a new set of labels. Now, this might all not be so bad if such a revolution were final. If the wheel were only weighted on one side, so that once it came to rest we could feel

that there it would stay, we might put up with temporary confusion in view of the peace that should certainly follow. But the revisers are by no means agreed among themselves. We are watching a wheel which is weighted, not on one side only, but on two or three different sides, and we not only have no idea which side will eventually determine equilibrium, but we are certain that any repose we may secure is liable to be instantly and forever jeopardized by the first crank who chooses to give our wheel again a whirl. Meanwhile revision and re-naming go merrily on. Rules have been adopted by bodies more or less representative, first on one side of the Atlantic then on the other, but neither do these rules agree one with another. The zoologists have their set of rules to which some are obedient, others not. The botanists have their set of rules which have gotten so far as to be liable to be submitted to a world's botanical congress, did such ever convene. Meantime, while nothing is settled, at least by anything like universal consensus of opinion, there are men who devote their energies, not to the pursuit of science, but of priority; who are forever claiming to find in the work of some obscure naturalist of a preceding century for common objects names different from those in universal use, and all the world must perforce stop in its real pursuit of knowledge to see what must be done with these disturbers of the peace, until we are in danger of presenting to our successors, if they heed us at all, the spectacle of a generation of so-called scientific men giving more heed to names than to things.

Now all this is trite enough. Moreover the question of nomenclature is a real one, a very real one, as it has to do with an instrument of research, and it is one of those questions that never can be settled until settled right.

It is not in the hope of being able to contribute far towards such settlement that the present paper is submitted, but rather to point out some of the difficulties to be encountered by one who attempts to deal with nomenclature, even in a group of organisms confessedly small.

As is well known the Myomycetes are a group of saprophytes, for a long time classed with the fungi and especially with the *Gastromycetes*, puff-balls, stink-horns and the like, and only recently, i. e., within twenty or thirty years, thoroughly studied and understood. Although not understood, not primarily properly referred at all, mycologists were continually

collecting them, in a fashion describing them, naming and occasionally figuring them. In 1873-75 Rostafinski, under direction of De Bary, undertook the first systematic presentation of the group as a whole, properly separating the slime moulds from the fungi, basing subsequent classification upon characters unused before, characters chiefly microscopic, and for the first time in the case of the great majority of the forms studied, offered specific descriptions sufficiently exact, and presented intelligible figures. I have said that Rostafinski based his specific descriptions upon characters revealed by a microscope: not only so but it must be considered that his work was effected by the aid of a *good* microscope, one which enabled him to go into details of spore measurement, spore sculpture and so on, to an extent to his predecessors undreamed, to most of them indeed impossible. In the preparation of his classic, he had access to all the literature of his subject and generally employs for genera and species names already in use. Furthermore he gives for all such species a synonomy which must strike every student as liberal in the extreme. For instance, in the case of *Fuligo varians* Sommf., the synonyms quoted number 42. But when it comes to selecting the particular name which he has adopted, Rostafinski was often somewhat arbitrary. Not only does he discard often the specific name which by his list of synonyms has conceded priority, much less does he follow the rule which adopts "the name given first with the genus in which the species now stands," but he seemed often to discard any and all names, and to name his species without regard to any rule, but purely in accord with his own taste or preference.

For twenty years Rostafinski's work has been unassailed, partly because of its inherent exellence and the great name of his master De Bary, which seemed to stand as a guarantee behind it, and partly no doubt because of the unintelligible Polish dialect in which the book was given to the world. The Germans let the thing alone as *opus perfectum*, the English botanists were content with Cooke's paraphrase and there the matter stood. Massee, in his Monograph of 1892, followed almost implicitly the Rostafinskian nomenclature, and even quoted his synonyms *intoto*. Meantime some continental writers, as Rannkier in Denmark, were becoming reckless, and Mr. Lister the latest English monographer, was preparing to overturn the whole Rostafinskian list. This author is not only extremely radical in his omission and consolidation of pre-

viously recognized species but adopts as his guide in nomenclature the rule "laid down by A. L. Condolle in 1868, * * * that the first authentic specific name published under the genus in which the species now stands shall take precedence of all others;" a rule which seems to me as unfair in its proposals as absurd in the results to which it leads. Under the operation of this rule Rostafinski's synonyms is made to overturn his own nomenclature, and this in a multitude of instances.

Now, I have no disposition to defend Rostafinski. As before said, his nomenclature, whatever apology we may offer, admits in many cases of small defense; but in fact Rostafinski needs no defender. If any man chooses some other prior name for a species listed by the illustrious Pole, upon him devolves the burden of proof; he must show that the form described by Rostafinski is that referred to by the earlier author. No one who has studied these forms and has attempted their specific identification, even with the most carefully drawn descriptions before him, but will appreciate the futility of an effort to apply the old and brief descriptions. Even so-called authentic specimens are hard to authenticate. Slime-moulds are perishable things and labels are liable to become mixed, even in the best herbaria as we all know. To aver of a species described by Rostafinski that it is the same as that sketched in a line or two by Persoon or Link, is an undertaking too bold for me. Even where the species described is figured, the figure is often perfectly valueless for complete assurance. Take Schrader for instance, whose copper plates of a hundred years ago are among the best pre-Rostafinskian illustrations in the group we study, and even these are disappointing in the extreme. The figure of *Dictydium umbilicatum* S. is portrayed in life-like fashion but is unluckily an only species. The species of *Cribraria* to which Schrader gave name, are some of them fairly shown but not in the details by which the species may be everywhere distinguished. *C. macrocarpa* the artist missed entirely and fell instead into a bit of arabesque which has nowhere the slightest counterpart in nature. Schrader's descriptions are very much better than those of most writers of his day, and yet they fail to distinguish as we now discriminate since Rostafinski taught us how. The fact is that when Rostafinski gives credit to his predecessors it is for the most part purely a work of courtesy and grace. There is nothing in the work itself to command such consideration. The man who in his search for

priority ascends beyond Rostafinski, does it therefore at the risk of endless confusion and uncertainty in the great majority of cases. Some years ago the botanists present at the session of the A. A. A. S., concluded that in describing Phenogams one should not transcend a particular edition of Linnæus; a better rule is that which ascends to the earliest accurate description; no farther. Accordingly for the great majority of slime-mould species I should draw the line at Rostafinski's work, 1875.

The exceptions are the few which the rule of accurate description would carry behind the Polish publication, where Rostafinski discarded a name simply because for some reason or other Rostafinski did not like it. As an illustration, take the little, not uncommon, species called by Rostafinski—

Cornuvia circumscissa (Wallr.) R.

The synonyms, as quoted by Rostafinski, are:

Lignidium quercinum Fr. 1825.

Trichia circumscissa Wallroth. 1833.

Arcyria glomerata Fr. 1849.

Ophiotheca chrysosperma Currey. 1854.

Trichia curreyi Cronan. 1867.

The only names accompanied by their authors by descriptions at all definitive are the last two. The genus Lignidium, as defined by Link, certainly referred to forms belonging to the *Physareæ*, if to Myomycetes at all, so that that generic name cannot stand, nor can Fries have had our species in mind, since his description refers, probably, to some *Physarum*. *Trichia circumscissa* Wallr. undoubtedly comes nearer to it, but our species is not circumscissile, so that it is doubtful whether Wallroth, even, had in view the same species. Currey, who comes next on the list, by judicious description and carefully drawn figures, having, as we think properly, separated from the Trichias the genus *Ophiotheca*, ignored all preceding specific names, supposing any to have been up to this time affixed, and called the species we have before us *O. chrysosperma*. Rostafinski now recognizes Currey's work, but rejects his generic name on the grounds of inapplicability in primary significance to all the species included. He therefore coins a new generic name—*i. e. Cornuvia*—and goes back to Wallroth for specific name, a thing that Currey should have done had Wallroth's description been of sufficient exactness to make sure to Currey's mind, as it seems it did to Rostafinski's, that Wallroth was actually describing the same specific form. The criticism of Rostafinski will,

therefore, in this instance, change the commonly received name. Instead of *Cornuvia circumscissa* (Wallr.) R., we shall say *Ophiotheca chrysosperma* Currey, unless we can show that Wallroth actually described the same thing, when, of course, we should write *Ophiotheca circumscissa* (Wallr.), followed by the name of the author who first established the combination, in this case, Massee.

NOTES ON THE FLORA OF WESTERN IOWA.

BY L. H. PAMMEL.

The flora of the loess in western Iowa is unique, in many respects. While it may be said that many parts of the state have a typical prairie flora, certain species being common from Texas to British America, east to Wisconsin, Illinois and Indiana, only occasionally do we find plants of the great plains in our own state. Western species are somewhat unequally distributed in our state; they occupy a larger area in northwestern Iowa than in southern and western. In northern Iowa a few prominent types appear, as in Emmet county. Of these I may mention *Bouteloua oligostachya*, *Agropyrum caninum*, *A. caesium*, *Grindelia squarrosa*, *Helianthus Maximiliani*. The latter is not, however, a typical western plant, though introduced in central Iowa. It crosses our western border on the loess and extends south to Texas.

The loess of western Iowa is peculiar so far as the flora is concerned, nothing like it in Iowa. A number of American writers have written upon the peculiarities of its plant life. B. F. Bush[1] has given us a complete catalogue of the flora of northwestern Missouri.

A. S. Hitchcock[2] has reported a few of the plants occurring near Sioux City, and in general touches on the flora of western Iowa.

J. W. McGee considers the loess flora of northeastern Iowa. The two regions are however not similar from a botanical standpoint. It may be well to speak of the formation in this

[1]Notes on the mound flora of Atchison county, Missouri. Reprint, Sixth Ann. Rep. Missouri Botanical Garden, 1895. pp. 121-134.

[2]Notes on the flora of Iowa, Bot. Gazette, Vol. XIV, p. 127

connection. McGee[3] says: "The macroscopic characters of the deposit are moderately constant:

"(1) It is commonly fine, homogeneous, free from pebbles or other adventious matter, and either massive or so obscurely stratified that the bedding plains are inconspicuous; (2) it commonly contains unoxidized carbonate of lime in such quantity as to effervesce freely under acids; (3) it frequently contains nodules and minute ramifying tubules of carbonate of lime; (4) in many regions it contains abundant shells of land and fresh water mollusca; (5) is commonly so friable that it may be removed with a spade or impressed with the fingers, yet it resists weathering and erosion in a remarkable manner, standing for years in vertical faces and developing steeper erosion slopes than any other formation except the more obdurate clastic or crystalline rocks." McGee also states that it is a fallacy to regard the loess as identical in composition or that it is identical in genesis or even in age. As to its origin, Chamberlin and Salisbury find that in western Wisconsin and contiguous parts of Illinois and Iowa its composition varies in different localities with that of the associated drift and that both composition and distribution point to glacial silt as the parent formation of the loess in the upper Mississippi valley. Prof. McGee in speaking of the plants of the loess in northeastern Iowa lays stress on the prevalence of hard wood forests in the area. That the timber belt is confined to this area. The chief trees of this region from my observations are, oaks a half dozen species (*Quercus macrocarpa*, *Q. coccinea*, *Q. tinctoria*, *Q. rubra*, *Q. alba*, *Q. Muhlenbergii*, *Q. bicolor*). The *Q bicolor* is however, a swamp species. The latter and *Q. Muhlenbergii* are southern species that have extended northward along the Mississippi. The butternut (*Juglans cinerea*) of the uplands and walnut (*Juglans nigra*) of the bottoms, the former is northern and the latter southern. The genus *Prunus* is represented by three species (*Prunus Americana*, *P. serotina*, and *P. Virginiana*). The crab apple (*Pyrus coronaria*) is found everywhere in thickets. The white birch (*Betula papyracea*) is a rare tree, the river birch (*Betula nigra*) is abundant along the streams; other trees along streams are honey locust (*Gleditschia triacanthos*); sycamore (*Platanus occidentalis*) Kentucky coffee tree (*Gymnocladus Canadensis*), all southern representatives. The elms are represented

[3]The Pleistocene history of northeastern Iowa, Eleventh Ann. Rep. U. S. Geological Survey, p. 291.

by three species (*Ulmus Americana*, *U. racemosa* and *U. fulva*). Only one, the slippery elm, is abundant on the loess formation, though *Ulmus Americana* is less restricted to low bottoms than *U. racemosa*. Of the maples the sugar maple (*Acer saccharinum*) is common on the loess, while the soft maple (*Acer dasycarpum*) is exclusively a lowland species, so is box elder (*Negundo aceroides*). The mountain maple (*Acer spicatum*) occurs on the loess. *Tilia Americana* is common on the loess formation. Three cone bearing trees occur in northeastern Iowa (*Abies balsamea*, *Pinus Strobus* and *Juniperus Virginiana*), but they occur on other than loess soil. Of the ashes there are several species the *Fraxinus viridis* delights in low bottoms. The *F. Americana* occurs on higher soil.

I cannot, in this connection, enumerate the shrubs that occur, but they are numerous and may occur in thickets in both loess and bottoms. Comparing the plants found in northeastern Iowa with those about La Crosse, Wis., where my early botanical work was done, I may say that most of the species occur and that the woody plants are more numerous. Some of the southern species, however, fail to appear, but in places northern forms occur. The density of the timber increases from the Mississippi east. In the drainage basin of the Kickapoo Valley the finest timber in western Wisconsin occurs. Nowhere have I seen such beautiful specimens of *Acer saccharinum*, *Tilia Americana* and *Quercus macrocarpa*. This, too, is outside of the loess region. In southwestern Minnesota, the statement of McGee that there is a significant relation between the loess sheeting and forest covering is very apparent.

The most significant fact appearing to one who has made a study of the loess flora of western Iowa is the absence of trees, except an occasional cottonwood, on the peculiar mounds that occur in parallel ridges along the Missouri river. These peculiar hills rise abruptly from the rich, fertile Missouri bottom and somewhat resemble the low foot hills of the Rocky mountains. They are from 100 to 200 feet high. From a distance they look bare, but a day spent in this region will show that the hills are full of botanical interest. I have made four botanical trips at different times along the Missouri. On the whole there is very little variation in the flora of Iowa. If we leave out of consideration a number of most interesting plants found in Winneshiek county by Mr. Holway and a few peculiar southern plants found by Mr. Ferd Reppert, near the city of

Muscatine, the only radical difference shown in our flora is that occurring along the Missouri. About twenty-five western and northwestern species occur and, according to the list of Mr. Bush, nearly the same species occur from Sioux City, Iowa, to St. Joseph, Mo. The region is not entirely devoid of trees, in its northern portion, between the steep mounds a variety of bur oak (*Quercus macrocarpa* var. *olivaeformis*), Slippery elm (*Ulmus fulva*), Cottonwood (*Populus moniliflera*), Plum (*Prunus Americana*), Basswood (*Tilia Americana*), box elder (*Negundo aceroides*), occur. Several shrubs also occur; Grape (*Vitis riparia*), climbing bittersweet (*Celastrus scandens*), wahoo (*Euonymus atropurpureus*). South, the timber area is more extensive, as at Council Bluffs and Missouri Valley. At Glenwood and Logan there are fine specimens of *Quercus rubra*, *Tilia Americana* and *Ulmus fulva*. They are abundant from one-half to two miles from the hills. The trees on the loess about Turin and Sioux City are broad and spreading.

Of the peculiar herbaceous plants, I shall content myself by giving a list. The beautiful Spanish bayonet (*Yucca angustifolia*) so abundant everywhere in the west. The *Aplopappus spinulosus* forms dense mats on the tops of the mounds. *Grindelia squarrosa*, now naturalized in other parts of Iowa. *Liatris punctata*, *Euphorbia marginata*, *E. heterophylla*, a beautiful blue-flowered lettuce (*Lactuca pulchella*), *Gaura coccinea*, so abundant everywhere in Nebraska and in the Rocky mountain region. *Oxybaphus angustifolia*, *Helianthus Maximiliani*, *Lygodesmia juncea*, an abundant plant of the plains now exerting itself with great force in the cornfields of northwestern Iowa. The beautiful *Mentzelia ornata* is confined to Cedar Bluffs along the Big Sioux a few miles north of Sioux City. *Cleome integrifolia*, the celebrated Rocky Mountain bee plant. Two species of *Dalea* (*D. alopecuroides* and *D. laxiflora*) the Loco weed (*Oxytropis Lamberti*) and *Astragalus lotiflorus*, var. *brachypus*. Professor Hitchcock records *Stipa comata*, which belongs chiefly to the Rocky Mountain region and rarely found in eastern Nebraska. *Shepherdia argentea* occurs along the Missouri near Sioux City undoubtedly a waif from the northwest.

I may also add a gamma grass peculiar to the west, most common species of Nebraska (*Bouteloua oligostachya*) Buffalo grass (*Buchloe dactyloides*) from Lyon county. The most abundant grasses on the hills are *Andropogon scoparius*, *Bouteloua racemosa*, quite common in many parts of Iowa. *Muhlenbergia*

soboliferia, *Ammophila longifolia* and *Sporobolus Hookeri*, *S. brevifolius* and an unnamed western species which has heretofore been referred to *S cuspidatus*. I may also remark that a peculiar thistle occurs, the *Cnicus altissimus*, var. *fililpendulus*.

Why is it that these peculiar hills, not more than a few hundred feet wide, should have such a local western flora? The soil is retentive of moisture, it dries out quickly and the roots easily penetrate the soil to draw on the contained moisture below. This certainly cannot be the reason, since the loess extends along the river courses in the interior. Some of these plants, since the cultivation of the soil, have shown some tendency to spread, as in *Euphorbia marginata*, *Lygodesmia juncea*, *Grindelia squarrosa*, which are tramping eastward to menace the farmer.

Were the seeds of some of these plants brought to Iowa with the buffalo, as has been suggested for buffalo grass? Some of the plants are disseminated by the wind, and in others the water can by a purely mechanical means bring them to the base of the mound. With the more woody country of southeastern Iowa there seems to have been but little chance for these plants to spread beyond the bluffs. In northwestern Iowa some of these plants, like *Helianthus Maximiliani*, are not uncommon, which shows that the woody area of southwestern Iowa is in part a barrier against a further eastern extension. But why did the plants not extend beyond the very narrow limits, as the forest area does not encroach directly on the loess mounds? I am at a loss to explain this most peculiar distribution.

In the list appended I enumerate the most striking plants. The writer is under obligations to Mrs. Rose Schuster Taylor and Miss Bandusia Wakefield, of Sioux City, for favors rendered; also Mr. E. D. Ball, of Little Rock; Mr. W. Newell and J. Jensen, of Hull, and E. G. Preston, of Battle Creek, for specimens, to Dr. Millspaugh for naming the Euphorbias.

My own collections were made at various times near Sioux City, Hawarden, Onawa, Turin, Missouri Valley, Council Bluffs and Logan. The list could have been extended and localities added, but college material is not readily accessible at this time of the year. Miss Wakefield's list is based on colored sketches in her possession. I have abbreviated all specimens credited to her as (B. W.), and those collected by myself as (L. H. P.). I have followed Gray's Manual in arrangement of

orders, genera and species. It will not be necessary to comment on the value of this, since it is the standard work in the schools and colleges of Iowa.

RANUNCULACEÆ.

Clematis Virginiana L.
Sioux City, in woody ravines (B. W.).

Anemone patens L. var. *Nuttalliana* Gray.
Sioux City, prairies, abundant (B. W.).

Anemone cylindrica A. Gray.
Hull (W. Newell); Little Rock, dry grounds (Herb. C. R. Ball).

A. Virginiana L.
Sioux City (B W.).

A. Canadensis L.
Sioux City, low grounds, bottoms (B. W.); Little Rock (Herb. C. R. Ball).

Thalictrum purpurascens L.
Sioux City, low grounds and prairies (B. W.); Hull (W. Newell); Little Rock (C. R. Ball).

Ranunculus Cymbalaria Pursh.
Hull (W. Newell); Little Rock (Herb. C. R. Ball).

R. multifidus Pursh.
Little Rock, in water (Herb. C. R. Ball).

R. abortivus L.
Sioux City (B. W).

R. septentrionalis Poir.
Cherokee (B. W.).

Caltha palustris L.
Sioux City, not common, low marshes (B. W.).

Aquilegia Canadensis L.
Sioux City, abundant in wooded ravines (B. W.).

Delphinium azureum Michx.
Sioux City prairies (B. W.); Little Rock (C. R. Ball); flowers of Iowa specimens are greenish white.

Actaea spicata L. var. *rubra*, Ait.
Sioux City woods, frequent (B. W.).

MENISPERMACEÆ.

Menispermum Canadense L.
Sioux City, common, in wooded ravines (B. W. L. H. P.).

BERBERIDACEÆ.

Caulophyllum thalictroides, Michx.
Sioux City woods, frequent (B. W.).

NYMPHAEACEÆ.

Nelumbo lutea Pers.
Onawa (B. W.).
Nymphaea reniformis D. C.
Lyon Co. (B. W.).
Nuphar advena Ait.
Sioux township Lyon Co , northwest corner of state (B. W.)

PAPAVERACEÆ.

Sanguinaria Canadensis L.
Sioux City. Wooded ravines (B. W.).

FUMARIACEÆ.

Dicentra cucullaria D. C.
Sioux City, abundant in wooded ravines in vegetable mould.
Corydalis aurea Willd.
Sioux City, borders of woods, common (B. W.).

CRUCIFERÆ

Lepidium Virginicum L.
Sioux City, waste places abundant (B W.)
L. apetalum Willd.
Not represented by specimens though abundant on mounds, fields and pastures in western Iowa (L. H. P.).
Capsella Bursa-pastoris Medic.
Sioux City (B. W.).
Brasssca nigra Koch.
Sioux City (B. W.).
B. Sinapistrum Boiss.
Sioux City (B. W.).
Sisimbrium officinale Scop.
Sioux City (B. W.); Battle Creek (E. G. Preston); Little Rock (C. R. Ball); roadside weed.
S. canescens, Nutt.
Sioux City (B. W.).
Erysimum cheiranthoides L.
Sioux City, rich soil, river bottoms (B. W.).
Nasturtium terrestre R. Br.
Sioux City (B. W.) low grounds; borders of ponds and streams.
Cardamine hirsuta L.
Little Rock (C. R. Ball).
Arabis, hirsuta Scop.
Sioux City (B. W.).

CAPPARIDACEÆ.

Polanisia graveolens, Raf.

Sioux City (B. W.).

Cleome integrifolia Torr. & Gray.

Onawa, Missouri Valley streets and loess mounds (L. H. P.) common (B. W.); common in the city (L. H. Pammel); from observation.

VIOLACEÆ.

Viola pedatifida Don.

Sioux City, prairies frequent (B. W.).

A. palmata L. var. *cucullata* Gray.

Sioux City, common in woods (B. W.).

Viola Canadensis L.

Sioux City, wooded ravines between loess mounds east of Sioux City (B. W.). Apparently out of its range.

CARYOPHYLLACEÆ.

Saponaria officinalis L.

Sioux City, escaped from cultivation (B. W.).

Silene stellata Ait.

Sioux City, woods common (B. W.); Hawarden, Council Bluffs, common borders of woods (L. H. P.).

Lychnis Githago Lam.

Sioux City, an introduced weed (B. W.); Rock Valley (Jensen & Newell); Little Rock (Herb. C. R. Ball).

Stellaria longifolia Muhl.

Sioux City (B. W.); Little Rock (C. R. Ball).

PORTULACACEÆ.

Portulaca oleracea L.

Sioux City (B. W.); an abundant weed everywhere in western Iowa.

Talinum teretifolium Pursh.

Sioux City (B. W.).

Claytonia Virginica L.

Smithland, in woods (B. W.).

MALVACEÆ.

Malva rotundifolia L.

Turin, Onawa, weed in streets and along roadsides (L. H. P.); Sioux City (B. W.); Little Rock (C. R. Ball).

Abutilon Avicennæ Gaertn.

Onawa, streets and waste places, abundant (L. H. P.); Sioux City (B. W.).

TILIACEÆ.

Tilia Americana L.

Sioux City, Turin, Missouri Valley, Council Bluffs, ravines between loess mounds (L. H. P.); back of mounds an abundant tree.

LINACEÆ.

Linum sulcatum Riddell.

Sioux City, top and sides of loess mounds, prairies (L. H. P.), (B. W.); Little Rock (C. R. Ball).

L. rigidum Pursh.

Sioux City, loess mounds, capsules and old stems only found by myself (L. H. P.); Hamburg (Hitchcock, Bot. Gazette, XIV, 128).

GERANIACEÆ.

Oxalis violaceæ L.

Sioux City, in woods frequent (B. W.); Little Rock (Herb. C. R. Ball).

O. corniculata L. var. *stricta* Sav.

Turin, Onawa, in woods and fields abundant (L. H. P.); Sioux City (B. W.).

Impatiens pallida Nutt.

Sioux City, in woods along streams (B. W.).

I. Fulva Nutt.

Sioux City, in woods along streams (B. W.).

RUTACEÆ.

Xanthoxylum Americanum Nutt.

Sioux City, common in woods (B. W.); South Dakota, opposite Hawarden, in valleys between hills (L. H. P.).

CELASTRACEÆ.

Celastrus scandens L.

Sioux City, common in woods between loess mounds (B. W. and L. H. P.).

Euonymus atropurpureus Jacq.

Sioux City, in woods between loess mounds (B. W., L. H. P.); South Dakota, opposite Hawarden (L. H. P.).

RHAMNACEÆ.

Rhamnus lanceolata Pursh.

Logan, low hills in woods (L. H. P.), Sioux City, level woodland near the Big Sioux river (B. W.).

Ceanothus Americanus L.

Turin, Missouri Valley, loess hills in open, grassy places (L. H. P.); Sioux City (B. W.).

C. ovatus Desf.

Council Bluffs, sides and tops of loess mounds (L. H. P.).

VITACEÆ.

Vitis riparia Michx.

Sioux City, valleys between loess mounds in woods (L. H. P.); South Dakota, opposite Hawarden (L. H. P.).

Ampelopsis quinquefolia Michx.

Sioux City, in woods; common (B. W.).

SAPINDACEÆ.

Acer dasycarpum Ehrh.

Sioux City, Hawarden; abundant in alluvial bottoms, along Big Sioux and Missouri rivers (L. H. P.).

Negundo aceroides Moench.

Sioux City, frequent along streams (B. W.).

Staphylea trifolia L.

Sioux City, in valleys between loess hills (B. W.).

ANACARDIACEÆ.

Rhus glabra L.

Sioux City, common border of loess mounds (B. W.) South Dakota, opposite Hawarden (L. H. P.).

R. Toxicodendron L.

Sioux City, common in valleys between loess mounds (B. W.).

POLYGALACEÆ.

Polygala verticillata L.

Sioux City, loess mounds (L. H. P. and B. W.).

LEGUMINOSÆ.

Baptisia leucantha Torr. and Gray.

Battle Creek, low places, prairie (E. G. Preston), Cherokee (B. W.).

Crotalaria sagittalis L.

Sioux City, bank of Big Sioux river, Cedar Bluffs (B. W.).

Trifolium pratense L

Sioux City (B. W.).

T. stoloniferum Muhl.

Sioux City (B. W.).

T. repens L.

Sioux City (B. W.).

Melilotus officinalis Willd.

Sioux City (B. W.), Council Bluffs (L. H. P.).

M. alba Lam.

Sioux City, along railroads, in streets, fields and roadsides, abundant (L. H. P. and B. W.), Onawa, Turin (L. H. P.).

Medicago sativa L.

Sioux City, in streets; not common, Council Bluffs (L. H. P.).

Hosackia Purshiana Benth.

Sioux City, loess mounds (B. W.).

Psoralea argophylla Pursh.

Sioux City, adundant on loess mounds (B. W.), high prairies and low, rich soil; Little Rock (Herb. C. R. Ball), Hull (W. Newell). A typical prairie plant, common throughout Iowa on dry hills.

Amorpha canescens L.

Sioux City, bottoms (B. W.), Missouri Valley (L. H. P.).

Dalea alopecuroides Nutt.

Near Lake Okoboji (B. W.), Missouri Valley, Sioux City, loess mounds; abundant; Hawarden, in open grounds (L. H. P.), Hamburg (Hitchcock Bot. Gazette, XIV, 128).

D. laxiflora Pursh.

Sioux City (B. W.). The species is abundant on the loess mounds about Sioux City, Missouri Valley and Turin, producing a long and thick root. Hamburg (Hitchcock, Bot. Gazette, XIV, 128).

Petalostemon violaceus Michx.

Sioux City abundant on loess hills (B. W., L. H. P.); Hull (W. Newell); South Dakota opposite Hawarden dry hills (L. H. P.); Logan (L. H. P.); Battle Creek (E. G. Preston); Little Rock (C. R. Ball); Council Bluffs dry hills (L. H. P.); Missouri Valley, Turin, loess hills (L. H. P.). On loess mounds, usually with shorter heads than commonly found on prairies.

P. *candidus* Michx.

Sioux City, hills loess abundant; L. H. P. South Dakota opposite Hawarden (L. H. P.); Hull (W. Newell); Battle Creek (E. G. Preston); Little Rock (Herb. C. R. Ball;) Council Bluffs, Turin, Missouri Valley, on loess mounds, shorter heads and smaller plants than commonly found on prairies.

Robinia Pseudacacia L.

Sioux City, an escape from cultivation (B. W.).

Astragalus caryocarpus Ker.

Sioux City (B. W.).

A. Canadensis L

Sioux City (B. W.).

A. lotiflorus Hook var. *brachypus* Gray.

Hamburg, Hitchcock, Bot Gazette XIV, 128.

Oxytropis Lamberti Pursh.

Sioux City (B. W.). Specimens in fruit were found near Turin and Missouri Valley on loess mounds (L. H. P.). Produces a perennial root several feet in length, frequently exposed where soil has washed away. Miss Wakefield finds the form with violet colored flowers more common than the white. Hamburg (Hitchcock, Bot. Gazette, XIV, 128).

Glycyrrhiza lepidota Nutt.

Sioux City (B. W.); Turin, Missouri Valley, along railroads, and border of hills common, Logan, Council Bluffs (L. H. P.). Hull (W. Newell); Little Rock (C. R. Ball).

Desmodium Canadense D. C.

Hull (W. Newell).

D. canescens D. C.

Sioux City, bottom (L. H. P.).

Apios tuberosa Moench.

Smithland, low grounds (B. W.).

Strophostyles angulosa Ell.

South Dakota, opposite Hawarden, flood plain of Big Sioux river (L. H. P.); Sioux City (B. W.).

Amphicarpæa monoica Nutt.

Sioux City (B. W.).

Cassia Chamæcrista L.

Missouri Valley, loess hills abundant (L. H. P.); Sioux City (B. W. and L. H. P.); South Dakota, opposite Hawarden (L. H. P.); Battle Creek (E. G. Preston).

Gymnocladus Canadensis Lam.

Sioux City (B. W.), abundant at the mouth of the Big Sioux river, in alluvial soil, base of hills (L. H. P.).

Gleditschia triacanthos L.

Sioux City, abundant along the river (B. W.).

Desmanthus brachylobus Benth.

Spirit Lake (B. W.).

ROSACEÆ.

Prunus Americana Marshall.

Council Bluffs, loess in valleys between mounds. South Dakota, opposite Hawarden forming thickets at the base of hills (L. H. P.), Sioux City (B. W.) the species forms dense thickets in western Iowa, fruit small.

P. Virginiana L.

Logan, in valleys between hills. Sioux City (B. W.); the species occurs in thickets mostly small shrubs.

Rubus strigosus Michx.

Sioux City, rare (B. W.).

R. occidentalis L.

Sioux City, not common (B. W.).

Geum album Gmelin.

Logan, in woods (L. H. P.); Sioux City (B. W.).

Fragaria Virginiana Mill. var. *Illinoensis* Gray.

Sioux City (B. W.).

Potentilla arguta Pursh.

Hull (W. Newell); Battle Creek, (E. G. Preston); Little Rock, (Herb. C. R. Ball); Sioux City (B. W.). The species is frequent in dry places in western Iowa, loess mounds.

P. Norvegica L.

Hull (W. Newell); Little Rock (C. R. Ball); Rock Valley, (J. F. Jensen and W. Newell); Sioux City (B. W.).

Var. *millelegrana* Watson.

Sioux City (B. W.).

Rosa Arkansana Porter.

Hull (M. Newell).

SAXIFRAGACEÆ.

Heuchera hispida Pursh.

Sioux City (B. W.).

Ribes gracile Michx.

Sioux City, in woods (B. W.) Council Bluffs, loess in woods (L. H. P.).

R. floridum L'Her.

Sioux City, in woods (L. H. P.); South Dakota, opposite Hawarden in woods, valleys and between hills.

CRASSULACEÆ.

Penthorum sedoides L.

Hull (W. Newell); Sioux City (B. W.).

ONAGRACEAE.

Oenothera biennis L.

Hull (W. Newell); Battle Creek (E. G. Preston); Little Rock (C. R. Ball); Council Bluffs (L. H. P.). A weed in streets and waste places, and fields abundant throughout western Iowa.

O. serrulata Nutt.

Sioux City (B. W.); Battle Creek (E. G. Preston); Little Rock (C. R. Ball); Hull (W. Newell). Praries and loess mounds abundant.

Gaura parviflora Dougl.

Sioux City, base of mounds (B. W.); Missouri Valley (L. H. P.). It is spreading eastward, occurring in meadows and fields.

G. coccinea Nutt.

Sioux City (B. W.) Missouri Valley, Turin top of loess mounds, common (L. H. P.); Hamburg (Hitchcock, Bot. Gazette XIV, 128).

LOASACEÆ.

Mentzelia ornata Torr. & Gray.

Sioux City on sandy and rocky bluffs along the Big Sioux river, Cedar Bluffs, abundant in that locality (B. W.).

CUCURBITACEÆ.

Echinocystis lobata Torr & Gray.

Turin, low ground along streams (L. H. P.).

CACTACEÆ.

Opuntia Rafinesquii Englem.

Lyon county (B. W.).

UMBELLIFERÆ.

Heracleum lanatum Michx.

Sioux City (B. W.).

Pastinaca sativa L.

A roadside weed. Council Bluffs, Sioux City (L. H. P.).

Cryptotœnia Canadensis D. C.

Sioux City (B. W.).

Zizia aurea Koch.

Sioux City (B. W.).

Cicuta maculata L.

South Dakota opposite Hawarden (L. H. P.); Sioux City (B. W.)

Osmorrhiza brevistylis D. C.
Sioux City (B. W.).
Eryngium yuccaefolium Michx.
Cherokee (B. W.).

CAPRIFOLIACEÆ.

Triosteum perfoliatum L.
Cherokee Co., Sioux City (B. W.)
Sambucus Canadensis L.
Sioux City (B. W.).
Symphoricarpos occidentalis Hook.
Sioux City, base of mounds; abundant (L. H. P. and B. W.); South Dakota, opposite Hawarden (L H. P.); Battle Creek (E. G. Preston); Rock Valley (W. Newell and J. F. Jensen); Little Rock (C. R. Ball); Council Bluffs, Missouri Valley, Turin, base of loess mounds; abundant (L. H. P.).

RUBIACEÆ.

Houstonia angustifolia Michx.
Logan, hills; Council Bluffs, Missouri Valley, loess mounds (L. H. P.); Smithland (B. W.), common everywhere on the hills.
Galium Aparine L.
Sioux City (B. W.).

COMPOSITÆ.

Vernonia fasiculata Michx.
Hawarden, Missouri Valley, Turin, low grounds (L. H. P.); Sioux City (B. W.).
V. Noveboracensis Willd.
Missouri Valley, Council Bluffs, loess mounds near base (L. H. P.).
Eupatorium purpureum L.
Sioux City (B. W.).
E. serotinum Michx.
Sioux City, Big Sioux bottom; not common (L. H. P.).
E. perfoliatum L.
Missouri Valley, low grounds (L. H. P), Sioux City (B. W.).
E. ageratoides L.
Sioux City (B. W.); Onawa, in woods and low grounds (L. H. P.).

Kuhnia eupatoriodes L.

Missouri Valley, Turin, loess mounds; Sioux City, loess mounds (B. W. and L. H. P.); Alton, prairies; South Dakota, opposite Hawarden (L. H. P.).

Liatris punctata Hook.

Missouri Valley, loess mounds (L. H. P.); Sioux City (B. W., L. H. P.); Hitchcock, South Dakota, opposite Hawarden, hills (L. H. P.).

L. scariosa Willd.

Alton, prairies, South Dakota, opposite Hawarden (L. H. P.).

Grindelia squarrosa Dunal.

Smithland (J. M. Wrapp), Sioux City, Hawarden, alluvial plain, Big Sioux river, abundant (L. H. P.); Battle Creek (E. G. Preston); Little Rock (Herb. C. R. Ball). Sioux City (Hitchcock, Bot. Gazette, XIV, 128).

Aplopappus spinulosus D. C.

Missouri Valley, Turin, Sioux City, tops of loess mounds, found in dense patches (L. H. P., B. W., Hitchcock, Bot. Gazette, XIV, 128).

Solidago speciosa Nutt.

Turin low grounds, border of woods (L. H. P.); Sioux City, base of hills (B. W.).

S. Missouriensis Nutt.

Turin, Missouri Valley, loess mounds common (L. H. P.).

S. serotina Ait.

Sioux City (B. W.).

S. rupestris Raf.

Sioux City, loess mounds (L. H. P.).

S. Canadensis L.

Sioux City, border of woods, thickets, roadsides, fences, pastures, abundant (L. H. P. B. W.); Onawa, Turin (L. H. P.).

S. rigida L.

Turin, loess hills (L. H. P.); Sioux City (B. W.).

Boltonia asteroides L'Her.

Missouri Valley, Turin, low bottoms, common (L. H. P.); Sioux City (B. W.).

Aster oblongifolius Nutt.

Turin, very abundant over loess mounds; South Dakota, opposite Hawarden, abundant all over low hills (L. H. P.); Sioux City, low mounds, common (B W., L. H. P.).

A. Novæ-Angliæ L.

Turin, borders of woods, common; South Dakota, opposite Hawarden, few specimens near spring (L. H. P.); Sioux City (B. W.).

A. sericeus Vent.

Sioux Rapids, prairies, Turin, Missouri Valley, abundant over loess mounds (L. H. P.); Sioux City (B. W.).

A. sagittifolius Willd.

Turin, low grounds (L. H. P.).

A. ericoides L.

Turin, low grounds (L. H. P.).

A. multiflorus Ait.

Missouri Valley, open places, woods (L. H. P.); Sioux City (B. W.).

A. paniculatus Lam.

Sioux City, bottoms (L. H. P.); A. ptarmicoides, Torr. & Gray. Little Rock, prairies (Herb. C. R. Ball).

Erigeron Canadensis L.

Sioux City (B. W.); a weed in fields and pastures throughout western Iowa (L. H. P. observations).

E. strigosus Muhl.

Rock Valley (W. Newell, J. F. Jensen); Little Rock, prairies (Herb. C. R. Ball).

E. Philadelphicus L.

Hull (W. Newell); Sioux City (B. W.).

Antennaria plantaginifolia Hook.

Sioux City (B. W.).

Silphium laciniatum L.

Council Bluffs, common around loess mounds (L. H P.); Sioux City (B. W.).

S. perfoliatum L.

Sioux City (B. W.).

Iva xanthiifolia Nutt.

Sioux City (B. W., L. H. P.); Onawa L. H. P.); Smithland (J. M. Wrapp). An extremely abundant weed everywhere in western Iowa, growing luxuriantly ten to twelve feet high in streets, vacant lots, dooryards, and around neglected buildings, etc.

Ambrosia trifida L.

Smithland (J. M. Wrapp); Sioux City (B. W.). A common weed along creeks and river courses in western Iowa (L. H. P.).

A. artemisiaefolia L.

Alton, Turin (L. H. P.); Sioux City (B. W.). A common weed in cultivated fields, pastures, meadows, along roadsides, vacant lots, and railroads.

A. psilostachya DC.

Council Bluffs, common weed along creeks and river courses in western Iowa (L. H. P.).

Xanthium Canadense Mill.

Sioux City, Turin (L. H. P.). In alluvial soil very abundant and weedy. South Dakota, opposite Hawarden, bottoms of Big Sioux river (L. H. P.).

Heliopsis scabra Dunal.

Sioux City (B. W.); Hull (W. Newell); Battle Creek, in woods (E. G. Preston); Little Rock (Herb. C. R. Ball).

Echinacea angustifolia DC.

Sioux City (B. W.); Hull (W. Newell); Battle Creek, abundant prairies (E. G. Preston); Council Bluffs, Logan (L. H. P.); Little Rock (Herb., C. R. Ball).

Rudbeckia laciniata L.

South Dakota, opposite Hawarden in woods abundant (L. H. P.); Sioux City (B. W.).

R. triloba L.

Onawa, low grounds, common (L. H. P.)

R. hirta L.

Sioux City (B. W.) Little Rock (Herb. C. R. Ball).

Lepachys pinnata Torr. & Gray.

Sioux City (B. W.) Council Bluffs (L. H. P.).

Helianthus annuus L.

Sioux City (B. W.); Hawarden (L. H. P.); Onawa, Missouri Valley, (L. H. P.). A common weed everywhere in western Iowa, flood plains, Missouri and Big Sioux rivers, streets and dooryards. (L. H. P.).

H. rigidus Desf.

Hawarden (L. H. P.); Sioux City (B. W.).

H. grosse-serratus Martens.

Sioux City, abundant in alluvial bottoms of Missouri river, and along river courses, creeks (L. H. P., B. W.); Onawa, Turin. One of the most conspicuous plants in September.

H. Maximiliani Schrad.

Sioux City, Loess hills along the Missouri and Big Sioux rivers. Alton, Sioux Rapids, Hawarden, occasionally in alluvial bottoms at Whiting; also observed near Bradgate further east (L. H. P.).

H. tuberosus L.

Sioux City, between loess mounds, common, Hawarden, Big Sioux bottom, common (L. H. P.).

Coreposis palmata Nutt.

Sioux City (B. W.); Hull (W. Newell); Battle Creek (E. G. Preston); Little Rock (Herb. C. R. Ball).

Bidens frondosa L.

Sioux City (B. W.).

B. chrysanthemoides Michx.

Sioux City (B. W.).

Helenium autumnale L.

Missouri Valley, low grounds, common (L. H. P.) Sioux City (B. W.).

Dysodia chrysanthemoides Lag.

Sioux City, hills, waste places, streets, along roadsides abundant (L. H. P., B. W.); Turin (L. H. P.).

Anthemis Cotula D. C.

Sioux City (B. W.); Little Rock (C. R. Ball).

Achillea millefolium L.

Sioux City (B. W.); Battle Creek, pastures (E. G. Preston); Little Rock (C. R. Ball.).

Crysanthemum Leucanthemum L.

Sioux City; escaped from cultivation (B. W.).

Artemisia Canadensis Michx.

Sioux City (B. W., L. H. P.); South Dakota, opposite Harwarden (L. H. P.).

A. Ludoviciana Nutt.

Sioux City (L. H. P.).

A. biennis Willd.

Sioux City (B. W).

Senecio aureus L.

Sioux City (B. W.)

Cacalia tuberosa Nutt.

Council Bluffs (L. H. P.); Smithland (B. W.).

Arctium Lappa L.

Sioux City (B. W.).

Cnicus undulatus Gray.

Sioux City, lower parts of loess mounds; abundant in places (L. H. P.).

C. altissimus Willd. var. *filipendulus* Gray.

Has been sent to me from western Iowa—Ruthven (D. Chapin); Sioux City (L. H. P.; Hitchcock Bot. Gazette, XIV,

129). This approaches *C. undulatus*. Miss Wakefield's *C. undulatus*, from Sioux City, is referable to this variety.

Var. *discolor* Gray.

Sioux City (B. W.).

C. arvensis Hoffm.

Maple River Junction (Bernholtz).

Krigia Dandelion Nutt.

Sioux City (B. W.).

Lygodesmia juncea Don.

Sioux City, loess mounds very abundant (L. H. P.); Logan, Missouri Valley, Turin (L. H. P.); Hull, weedy (James C. Watson); Little Rock, weedy (C. R. Ball); Battle Creek, roadsides, weedy (E. G. Preston). Very abundant tops and sides of mounds. In August and September most of the plants are affected with galls.

Taraxacum officinale Weber.

Sioux City (B. W.).

Lactuca Scariola L.

Missouri Valley (L. H. P.). Common in streets of Council Bluffs, Onawa, Turin (L. H. P. observations).

L. Canadensis L.

Sioux City (B. W.).

L. integrifolia Bigel.

Lake Okoboji (B. W.).

L. pulchella Bigel.

Sioux City, base of loess mounds and in streets (B. W., L. H. P.).

LOBELIACEÆ.

Lobelia syphilitica L.

Sioux City (B. W.).

L. spicata Lam.

Rock Valley (C. R. Ball), Sioux City (B. W.).

CAMPANULACEÆ.

Campanula Americana L.

Sioux City (B. W.), Hull (W. Newell).

ERICACEÆ.

Monotropa uniflora L.

Smithland, in rich woods (B. W.).

PRIMULACEÆ.

Steironema ciliatum Raf.

Rock Valley (J. Jensen and W. Newell), Sioux City (B. W.).

S. lanceolatum Gray.
Little Rock (C. R. Ball).

APOCYNACEÆ.

Apocynum cannabinum L.
Little Rock (C. R. Ball), Sioux City (B. W.).

ASCLEPIADACEÆ.

Asclepias tuberosa L.
Hull (W. Newell), Sioux City (B. W.).
A. incarnata L.
Hull (W. Newell), Sioux City (B. W.).
A. Cornuti Decaisne.
Sioux City (B. W.), Little Rock (C. R. Ball).
A. ovalifolia Decaisne.
Sioux City (B. W.).
A. verticillata L.
Sioux City, loess mounds, common in open places (B. W., L. H. P.); South Dakota, opposite Hawarden, hills; Turin, Missouri Valley (L. H. P.); Rock Valley (J. F. Jensen and W. Newell).
Acerates virdiflora Ell.
Little Rock (C. R. Ball).

GENTIANACEÆ.

Gentiana puberula Michx.
Sioux City, grassy low lands and hills; not common (B. W.).
G. Andrewsii Griseb.
Sioux City, meadows of Missouri river bottom (B. W.).

POLEMONIACEÆ.

Phlox pilosa L.
Sioux City (B. W.); Little Rock (C. R. Ball).
P. divaricata L.
Sioux City, in rich woods (B. W.).
Polemonium reptans L.
Cherokee, in rich woods (B. W.).

BORRAGINACEÆ.

Echinospermum Virginicum Lehm.
Sioux City, woods, along streets and roadsides (B. W.).
Lithospermum canescens Lehm.
Sioux City, prairies, and loess mounds (B. W.)
L. angustifolium Michx.
Sioux City, prairie and loess mounds (B. W.).

Onosmodium Carolinanum D. C. var. *molle*, Gray.

Sioux City, prairies and common on loess mounds (B. W.); Little Rock (C. R. Ball); Council Bluffs, loess woods, South Dakota opposite Hawarden, border of woods, hills (L. H. P.).

CONVOLVULACEÆ.

Convolvulus sepium L.

Sioux City (B. B.); a common weed in fields, and pastures, gardens and meadows (L. H. P. observations).

Cuscuta glomerata Choisy.

Sioux City on Heilanthus, Solidago, common (B. W.).

SOLANACEÆ.

Solanum nigrum L.

Sioux City (B. W.).

S. Carolinense L.

Introduced; Mapleton (Abjah Lamb); Logan, along roadsides, Council Bluffs in streets (L. H. P.).

S. rostratum Dunal.

Woodbine; South Dakota, opposite Hawarden (L. H. P.).

Physalis pubescens L.

Sioux City B. W.); A very common weed in neglected yards Missouri Valley, Council Bluffs, Onawa (L. H. P. observations).

SCROPHULARIACEÆ.

Scrophularia nodosa L. var. *Marilandica* Gray.

Sioux City (B. W.); Little Rock (C. R. Ball).

Pentstemon grandiflorus Nutt.

Sioux City, common on the sides of the loess mounds (L. H. P., B. W.).

Mimulus ringens L.

Sioux City in low grounds (B. W.).

Ilysanthes riparia Raf.

Sioux City, low grounds and muddy places (B. W.); Hawarden (L. H. P.); Hull (W. Newell).

Veronica Virginica L.

Sioux City (B. W.); Hull (W. Newell); Little Rock (C. R. Ball).

Gerardia aspera Dougl.

Sioux City, common on sides and tops of loess mounds (L. H. P.).

G. tenuifolia Vahl.

Missouri Valley, loess mounds (L. H. P.).

Castilleia sessiliflora Pursh.
Sioux City, abundant on loess mounds (B. W.).

LENTIBULARIACEÆ.

Utricularia vulgaris L.
Hull (W. Newell).

PEDALIACEÆ.

Martynia proboscidea Glox.
Missouri Valley, in fields, base of hills (L. H. P.).

VERBENACEÆ.

Verbena urticæfolia L.
Sioux City (B. W.); Hull (W. Newell); Turin, Missouri Valley, low grounds (L. H. P.).
V. hastata L.
Sioux City, fields and low ground (B. W.); Hull (W. Newell).
V. stricta Vent.
Sioux City, base of loess mounds, prairies and fields, abundant (B. W.); Battle Creek (E. G. Preston); Little Rock (C. R. Ball); Turin, Missouri Valley (L. H. P.).
Phryma leptostachya L.
Sioux City (B. W.).

LABIATÆ.

Teucrium Canadense L.
Sioux City, low grounds, abundant (B. W.); Council Bluffs, abundant (L. H. P.).
Mentha Canadensis L.
Sioux City (B. W.); Hull (W. Newell); Little Rock, low grounds (C. R. Ball).
Lycopus sinutus Ell.
Sioux City (B. W.); Hull, low grounds (W. Newell).
L. Virginicus L.
Sioux City (B. W.).
Hedeoma hispida, Pursh.
Sioux City (B. W.).
Pycnanthemum lanceolatum Pursh.
Spirit Lake (B. W.).
Salvia lanccolata Willd.
Council Bluffs (L. H. P. observations).
Monarda fistulosa L.
Logan, prairies and borders of woods (L. H. P.).
Lophanthus scrophulariæfolius Benth.
Sioux City (B. W.).

Nepeta Cataria L.

Sioux City (B. W.). A common weed in western Iowa (L. H. P.).

Scutellaria lateriflora L.

Turin, rich, low woods near stream (L. H. P.); Sioux City (B. W.).

S. parvula Michx.

Little Rock (C. R. Ball); Sioux City (B. W.).

Physostegia Virginiana Benth.

Sioux City, low grounds (B. W.).

Stachys palustris L.

Sioux City, low grounds (B. W.); Rock Valley (J. Jensen, W. Newell).

PLANTAGINACEÆ.

Plantago major L.

Sioux City (B. W.).

P. Patagonica Jacq., var. *gnaphalioides* Gray.

Rock Valley (J. Jensen, W. Newell).

NYCTAGINACEÆ.

Oxybaphus hirsutus Sweet.

Hull (W. Newell); Sioux City, common along roadsides and fields (B. W.); Little Rock (C. R. Ball).

O. angustifolius Sweet.

Sioux City, loess hills near top (L. H. P.).

AMARANTACEÆ.

A. retroflexus L.

A common weed everywhere in western Iowa (L. H. P.); Sioux City (B. W.).

A. albus L.

Sioux City (B. W.); Onawa, Turin, a common weed (L. H. P.).

A. blitoides Watson.

Sioux City, loess mounds in open places (L. H. P.).

Acnida tuberculata Mcq.

Onawa, common weed in cultivated ground (L. H. P.).

CHENOPODIACEÆ.

Onawa, Turin, Des Moines (L. H. P.); Smithland (J. M. Wrapp); Sioux City (B. W.).

C. urbicum L.

Onawa, Missouri Valley, Turin near stables and houses (L. H. P.).

C. hybridum L.
Missouri Valley, Turin, Onawa (L. H P.); Sioux City (B. W.), a common weed in waste places.

Salsola Kali L., var. *tragus* Mcq.
Onawa, Sioux City, Missouri Valley, Hawarden, Council Bluffs (L. H.P.), spreading rapidly.

POLYGONACEAE.

Rumex verticillatus L.
Missouri Valley, in swamps, common (L. H. P.).

R. crispus L.
Council Bluffs, weed in streets (L. H. P. observations).

R. maritimum L.
Sioux City (B. W.); Little Rock (C. R. Ball), in low grounds.

R. Acetosella L.
Missouri Valley, Turin, weedy in yards and fields (L. H. P.).

Polygonum aviculare L.
Sioux City (B. W.); Hawarden, weed in yards (L. H. P.); Missouri Valley.

P. erectum L.
Missouri Valley, common weed in streets (L. H. P).

P. *ramosissimum* Michx.
Missouri Valley, Sioux City, L. H. P., B. W.) Hawarden (L. H. P.).

P. lapathifolium L., var. *incarnatum* Watson.
Sioux City, (B. W.); Turin, low grounds (L. H. P.).

P. Pennsylvanicum L.
Logan, Turin, Onawa, Missouri Valley, low grounds, (L. H. P.); Hull (N. Newell).

P. Muhlenbergii Watson.
Sioux City (B. W.), common along the Missouri river (L. H. P.).

P. Persicaria L.
Hull (W. Newell); Sioux City (B. W.).

P. orientale L.
Missouri Valley, an escape from cultivation (L. H. P.).

P. acre HBK.
Hull (W. Newell).

P. Virginianum L.
Sioux City (B. W.).

P. Convolvulus L.
Sioux City (B. W.), Hull (W. Newell).

P. dumetorum L., var. *scandens* Gray.
Sioux City (B. W.).

ARISTOLOCHIACEÆ.

Asarum Canadense L.
Cherokee (B. W.).

ELÆAGNACEÆ.

Shepherdia argentea Nutt.
Sioux City, sandy banks of Missouri river (B. W., L. H. P., Hitchcock, Bot. Gazette, XIV, 128).

EUPHORBIACEÆ.

Euphorbia maculata L.
Missouri Valley, Des Moines, Turin and Onawa; waste places and along railroad (L. H. P.).

E. hypericifolia.
Onawa (L. H. P.), Sioux City (B. W.).

E. marginata Pursh.
South Dakota, opposite Hawarden, hills, Missouri Valley, Turin and in waste places (L. H. P.), Hull (W. Newell), Council Bluffs (L. H. P.), Sioux City (B. W., L. H. P.).

E. corollata L.
Missouri Valley (L. H. P.), Sioux City (B. W.).

E. serpens H. B. K.
Missouri Valley, low grounds (L. H. P.).

E. serpyllifolia Pers.
Turin (L. H. P.), Sioux City (B. W.).

Var. *consanguinea.*
Onawa, Turin (L. H. P.).

E. glyptosperma Engelm.
Missouri Valley (L. H. P.).

Var. *pubescens.*
Turin (L. H. P.).

E. hexagona Nutt.
Missouri Valley (L. H. P.), Sioux City (B. W.).

E. Geyeri Engelm.
Missouri Valley (L. H. P.)

E. heterophylla L.
Sioux City, in woods, Council Bluffs (L. H. P.); Sioux City (B. W).

E. obtusata Push.
Sioux City (B. W.).

Acalypha Virginica L.
Sioux City (B. W.)

URTICACEÆ.

Ulmus fulva Michx.

Sioux City, in valleys between loess mounds (B. W., L. H P.); South Dakota opposite Hawarden.

U. Americana L.

Sioux City, along the Big Sioux river and Missouri river (B. W., L. H. P.).

Celtis occidentalis L.

Sioux City, along Missouri and Big Sioux rivers (L. H. P.).

Cannabis sativa L.

Missouri Valley (L. H. P. observations); Sioux City (B. W.).

Humulus Lupulus L.

Sioux City (B. W.).

Urtica gracilis Ait.

Sioux City (B. W.); Little Rock (Herb. C. R. Ball.).

Laportea Canadensis Gaudichaud.

Sioux City (B. W.).

Pilea pumila Gray.

Logan (L. H. P.)

Parietaria Pennsylvanica Muhl.

Turin (L. H. P.).

JUGLANDACEÆ.

Juglans nigra L.

Sioux City (B. W.).

Carya olivæformis Nutt.

Sioux City (Hitchcock); this is further north than it occurs elsewhere in this state.

C. amara Nutt.

Smithland (B. W.).

CUPULIFERÆ.

Corylus Americana Walt.

Sioux City (B. W.).

Ostrya Virginica Willd.

Council Bluffs, in woods, back of steep mounds (L. H. P.); Logan (L. H. P.); Sioux City (B. W.).

Quercus macrocarpa Michx.

Council Bluffs (L. H. P.).

Var. *olivæformis* Gray.

Sioux City, sides of bluffs (L. H. P., B. W.)

Q. rubra L.

Sioux City (B. W.).

SALICACEÆ.

Salix humilis Marsh.

Sioux City, common on prairies and at base of loess mounds (L. H. P.).

S. longifolia Muhl.

Sioux City (B. W.).

Populus monilifera Ait.

Missouri Valley, in bottoms near streams, in swales between loess mounds; occasionally near top of mound. Common (L. H. P.), South Dakota, opposite Hawarden (L. H. P.); Sioux City (B. W.).

CERATOPHYLLACEÆ.

Ceratophyllum demersum L.

Sioux City (B. W.).

CONIFERÆ.

Juniperus Virginiana L.

Sioux City (B. W.).

ORCHIDACEÆ.

Orchis spectabilis L.

Sioux City (B. W.).

Habenaria leucophæa Gray.

Cherokee (B. W.).

Spiranthes cernua Richard.

Smithland (B. W.).

Cypripedium pubescens Willd.

Cherokee, Smithland (B. W.).

IRDIACEÆ.

Iris versicolor L.

Sioux City (B. W.).

LILIACEÆ.

Smilax herbacea D.

Sioux City (B. W.).

Allium stellatum Fras.

Alton, common on prairies (L. H. P.).

A. Canadense Kalm.

Sioux City (B. W.).

Yucca angustifolia Pursh.

Council Bluffs, Missouri Valley, Sioux City, Turin (L. H. P.); near top of loess, mounds common. South, north and west sides. Many seeds produced. Not all the plants which flower produce seeds—many empty stalks were found. It is a significant fact that this species does

not occur on the east slopes of the mounds, perhaps because they are more or less wooded about Council Bluffs and Missouri Valley. Sioux City (B. W.), Hitchcock Bot. Gazette, XIV, p. 128.

Polygonatum giganteum Dietr.

Sioux City (B. W., L. H. P. observations). Deep rich woods.

Smilacina stellata Desf.

Sioux City (B. W.).

Uvularia grandiflora Smith.

Sioux City (B. W.).

Erythronium albidum Nutt.

Sioux City (B. W.).

Lilium Philadelphicum L.

Little Rock (Herb., C. R. Ball).

L. Canadense L.

Sioux City (B. W.).

Trillium nivale Riddell.

Cherokee (B. W.).

Zygadenus elegans Pursh.

Little Rock (Herb., C. R. Ball).

COMMELINACEÆ.

Tradescantia Virginica L.

Sioux City (B. W.).

JUNCACEÆ.

Juncus tenuis Willd.

Sioux City (B. W., L. H. P. observations).

J. nodosus.

Sioux City (B. W.).

TYPHACEÆ.

Typha latifolia L.

Sioux City (B. W.).

Sparganium eurycarpum Engelm.

ARACEÆ.

Dickinson Co. (Hitchcock); Hull (W. Newell).

Arisaema triphyllum Torr.

Sioux City (B. W.).

ALISMACEÆ.

Alisma plantago L.

Sioux City (B. W.).

Echinodorus rostratus Nutt.

Sioux City, Big Sioux river (L. H. P.).

NAIADACEÆ.

Potamogeton natans L.
Lake Okoboji (Hitchcock).
P. lonchites Tuck.
Spirit Lake (Hitchcock).
P. praelongus Wulf.
Clear Lake (Hitchcock).
P. perfoliatus L. var. *Richardsonii*, Bennett.
Lake Okoboji and Spirit Lake (Hitchcock).
P. zosterifolius Schum.
Lake Okoboji (Hitchcock).
P. mucronatus Schrad.
Spirit Lake (Hitchcock).
P. pectinatus L.
Woodbine (Burgess); Lake Okoboji (Hitchcock)

CYPERACEAE.

Cyperus diandrus Torr.
Near Lake Okoboji (B. W.).
C. Schweinitzii Torr.
Lake Okoboji (B. W.).
Eleocharis acicularis R. Br.
Sioux City (B. W.; L. H. P.).
Scirpus lacustris L.
Council Bluffs (L. H. P. observations); Sioux City (B. W.).
S. atrovirens Muhl.
Sioux City (B. W.).

Species of Carex numerous, but omitted because they have not been studied critically. There are also a large number of grasses, localities and species will appear in another connection.

SOME NOTES ON CHROMOGENIC BACTERIA.

L. H. PAMMEL AND ROBERT COMBS.

Quite a large list of chromogenic bacteria are known to bacteriologists. Many of these are familiar objects in bacteriological laboratories. Of the early works describing these in this country we may mention Sternberg and Trelease. For later works on North American chromogenic bacteria we must refer to Sternberg, Jordan and the numerous text books dealing with pathogenic species.

Very few attempts have been made to study our local bacteriological floras. It is indeed a very difficult matter.

The following works describe Chromogenes:

Saccardo: Sylloge Fungorum VIII.

Sternberg: Manual of Bacteriology. 1892.

Trelease: Observations on several Zoogloea (Studies Biol. Lab. of the Johns Hopkins University). 1885.

P. & G. C. Frankland: Micro-organisms in Water. 1894.

Adametz: Die Bakterien der Trink-und Nutzwasser. Mitth. der Oester Versuchstation fur Brauerei-und Malzerei in Wien, 1888. Heft 1.

Jordan: A report on certain species of bacteria observed in sewage. Rep. Mass. State Board of Health, 1888-1890, plate II.

Eisenberg: Bakteriologische Diagnostik. 1888.

Welz: Bakteriologische Untersuchnyer der Freiburger Luft, Zeiritschrift fur Hygiene XI, p. 121.

No attempt will be made to give description of common species found here at Ames, simply a record of their occurrence including some laboratory observations.

Micrococcus cyanogenus. N. SP.

Source.—During the latter part of May, 1894, a foreign blue color was observed on an old milk culture of an organism obtained from cheese; later the same was found in an old milk culture of *Bacillus aromaticus.* A transfer from the first milk tube was made to another tube of sterilized milk, the typical color appearing in three or four days. The organism was separated by pouring plates of agar.

Morphology.—A small micrococcus occurring singly or in groups; motility not determined. An aerobic liquefying micrococcus.

Agar.—Nearly colorless, with a slight tinge of blue, producing an irregular film on surface, growing at temperature of room.

Gelatin.—A creamy white layer not spreading on surface, soon liquefying, forming a funnel-shaped area, later the medium was liquefied with a creamy white sediment in the bottom of the tube.

Milk.—Sterilized milk inoculated produces in three days a slight blue layer on surface, which increases in intensity, becoming quite blue for one-third of an inch on the seventh day. On the eighth day it appeared rather muddy; on the ninth day only a faint blue color remained; it coagulated milk with a

blue liquid on top. The curd was dissolved slowly. In twenty-five days the process was completed, excepting a small portion in the bottom of the flask.

Dunham's peptone solution.—No color produced; the medium became cloudy, which was in no way characteristic. It failed to grow in Dunham's rosalic acid solution.

Several blue organisms have been described.

Bacillus cyanogenus is a well known inhabitant of milk. This is a non-liquefying, actively motile bacillus. Has not been found here at Ames. Gessard has shown that in presence of an acid it produces an intense blue color, and in milk not sterilized containing lactic acid germs, a sky blue color is produced.

Jordan has also described a *Bacillus cyanogenus*, which is less motile forming a deep brown color on potato, but he says undoubtedly *Bacillus cyangenus*. Beyerinck[2] has also described a blue organism obtained from cheese, the *Bacillus cyaneo-fuscus*. The original paper has not been seen but according to the description given by Sternberg this is a small bacillus 0.2-0.6 u. long and one half as thick. It is an aerobic liquefying motile bacillus, and when cultivated in a solution containing one-half per cent of peptone the culture media acquires at first a green color, which later changes to blue, brown and black. Subsequently the color is entirely lost. More recently Wm. Zangemeister[3] has described a bacillus cyaneo-fluorescens.

This species is in many respects similar to *Bacillus cyanogenus*. It is however somewhat shorter and very actively motile.

Gelatin is not liquefied and the bright greenish fluorescent pigment diffuses through it.

Our species also came from cheese and the blue color disappears, but the organism in question never produces a black color. The species so far as we have been able to determine is new, and we have therefore given it the name of *Micrococcus cyanogenus*.

Staphylococcus pyogenes, Ogston var. *aureus* Rosenbach.—This, the most common of the pyogenic micrococci has been found quite frequently here at Ames. It has at different times been isolated from ordinary carbuncle, fistula, dirt under the finger nails, etc. It has been found more commonly in suppurative abscesses than any other organism. It is pathogenic to mice

[2]Sternberg: Manual of Bacteriology p. 727.

[3]Kurze Mitteilungen uber Bakterien der-blauen Milch. Centralblatt f. Bakt. u Parsitenkunde. Erste Abt., XVIII, p. 321.

and rats. Old cultures, however, soon loose their virulence. A culture nine months old failed to cause any lesions in mice, not even the local formation of pus.

St. pyogenes, Ogston var. *citreus* Passet.—This species has not been found spontaneously in any of the cases of pus studied, though it has been cultivated in the laboratory. It has been included with the pyogenic cocci because of its occurrence in pus. Passet found the organism in the pus of an acute abscess and Sternberg[1] says: "As to its pathogenic properties, we have no definite information. It is included among the pyogenic bacteria because of occasional presence in the pus of acute abscesses, although it has heretofore only been found in association with other micro-organisms." Mice have been inoculated here at Ames but in no case did fatal septicæmia follow. We have, however, had no trouble in obtaining pus at the point of inoculation under the root of the tail. From this pus, pure cultures of the organisms were obtained.

St. pyogenes Ogston var., *flavescens* Trev.—Obtained from the fistula of a horse by Dr. S. Whitbeck in bacteriological laboratory, Iowa Agricultural college. This organism does not differ from the foregoing in size; in color, however, it is much paler, being an ochre yellow. It produces fatal septicæmia in mice when fresh cultures were used, but in this case pure cultures were not obtained.

Streptococcus cinnabareus, Flügge.—Obtained at first from butter, but probably came either from the air or water. Color in different media is quite constant, except in blood serum, where its color is much paler. It grows quite characteristic on the surface of bouillon, forming spherical masses paler than in agar or potato. A nearly related species was isolated by Dr. W. B. Niles from the heart of a diseased steer affected with corn-stalk disease. It differs from the cinnabarcus in the change of color. It is dark lemon-yellow at first, and then changes to a brick-red. This species will be described in another connection.

Sarcina lutea Schröter.—This well known organism occurs chiefly in the air. Gelatin and agar plates exposed to the air invariably show this organism. It comes up somewhat more tardily than the non-chromogenic species. They appear as small, yellow, spherical colonies. The canary-yellow growth liquefies gelatin quite slowly. The same organism has been

[1]Manual of Bacteriology p. 273.

obtained frequently from butter and milk, but the organism undoubtedly came from the air.

S. aurantiaca Flügge.—This organism is also quite commonly met, and appears on gelatin and agar plates exposed to the air.

Bacillus fluorescens liquefaciens Flügge.—This common inhabitant of water also occurs on potato, milk and butter. Scarcely a sample of water can be plated without obtaining this organism.

B. pyocyaneus Gessard.—This has been obtained several times from wounds and Dr. S. Whitbeck obtained a pure culture in open synovial bursa. Inoculation into the peritoneal cavity was followed by death in forty-eight hours. In old cultures there is a gradual tendency for the organism to lose its power of forming coloring matter. Gessard[5] has isolated two pigments a fluorescent green and a blue, the latter called pycoyanin.

Bacillus prodigiosus Ehrenberg.—This species is well known to most bacteriologists. It has long attracted attention because of the red stains produced on potatoes, boiled bread, and the red color it imparts to milk. According to several investigators this organism is not a native to this country.

The species is however, recorded at Ames by Bessey. He commonly obtained a red organism on sliced potatoes exposed to the air.

There are of course several red organisms and as the organism was reported before the era of modern bacteriological methods I must therefore express some doubt as to the correct determination of the Bacillus prodigiosus found by Bessey. The senior writer has at various times had cultures of this organism in the laboratory. Thus we had good growing cultures in 1889, 1892, but all attempts to make old cultures failed. In 1894 a blood-red colony came up in culture plate. Cultures of this organism had never been in this laboratory so far as we know. In the spring we had received from Dr. Irving W. Smith, cultures of several species obtained from the laboratory of Johns Hopkins University. The cultures appeared pure but they may have been contaminated. The senior writer observed this organism on one other occasion in the botanical laboratory of the Shaw School of Botany, St. Louis. Cultures of *B. prodigiosus* were obtained from rotting sweet potatoes, but European cultures were common at the time in the labora-

5Gessard. De la pyocyanine et de son Microbe. These de Paris, 1882. Nouvelles recherches sur la Microbe pyocyanique. Ann. d l'*Institut Pastcur*. Vol. IV, 1890, p. 89

6Bull. Dept. of Botany, Nov. 1884.

tory. Professor Trelease thought it probable that the species came from the European cultures. We are therefore inclined to believe with Jordan, Russell, and others that the species is not native in this country.

FUNGUS DISEASES OF PLANTS AT AMES, IOWA, 1895.

BY L. H. PAMMEL AND GEO. W. CARVER.

In previous papers record has been made of the abundance of parasitic fungi for the years of 1891, 1892, 1893 and 1894.[1] We hope to continue these observations for the purpose of making comparison.

Observations from year to year with climatic conditions should make it possible to say how much climate modifies the appearance of disease. Observations in a climate like ours are valuable because of the changeable conditions as to humidity and rainfall. From the nature of the diseases of plants it is difficult to make exact statements. We must speak in relative terms. In 1893 *Puccinia graminis*, *P. rubigo-vera* and *P. coronata* were very destructive. In 1894 these rusts were not absent, but they were not destructive; in fact, scarce as compared with 1893.

In the study of diseases of plants the condition of the atmosphere with reference to moisture is an important factor. The universally low humidity of the atmosphere in 1894, no doubt, largely determined the amount of rust that year. So low was the humidity that during the growing season dew was an unusual condition.

We append table, giving rainfall, relative humidity, 7 A. M. temperature (maximum and minimum), for the months of May, June, July, August and September, taken from the records made at Ames by Dr. J. B. Weems, Mr. W H. Heileman.

[1] L H. Pammel, Jour. Mycology, VII, p. 95.
Agricultural Science, VII, p. 20.
Proc. Iowa Academy of Science, II, p. 201-203

MAY.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
Rainfall	.03	.36	.38	....	.02	1.18	....	....	....	.11	...	....	....	....	.17	....	....	....	....	....	....	....	....	....	..	....	.08	....	....	1.95	....
Rel. hum. 7:00 a. m.	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
Temperature—max.	76	75	85	80	75	79	80	89	93	64	63	63	53	53	60	59	69	64	63	62	67	72	77	80	69	74	86	93	88	88	86
Temperature—min..	60	59	56	61	59	56	56	52	61	44	37	29	38	31	43	39	42	47	35	36	31	32	49	40	57	40	40	69	72	70	66

JUNE.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
Rainfall	...	1.06	.08	....	....	....	.12	...	.36	.44	...	....	.40	.99	....	.47	....	....	....	....	....	....	.43	.24	.44	.03	.20	....	....	....	....
Rel. hum. 7:00 a. m..	95	78	78	76	71	78	79	71	63	95	99	95	84	94	71	74	90	78	70	85	75	85	90	86	69	79	89	77	88	75	....
Temperature—max.	90	85	83	68	77	84	84	88	86	69	77	81	81	81	85	84	80	76	80	85	80	84	84	88	74	74	72	69	74	81	....
Temperature—min..	67	64	50	48	49	60	57	66	64	62	55	51	56	56	60	62	57	50	56	57	54	60	60	65	57	49	49	50	56	54	....

JULY.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
Rainfall..	....	....	....	....	....	....	....	....	....	....	....	....	....	.18	.22	....	.82	....	....	.89	....	....	....	....	.29	....	.38	.09	....	....	....	....
Rel. hum. 7:00 a. m ..	85	90	99	86	86	66	77	71	81	65	71	95	95	95	95	95	72	95	95	99	99	89	90	90	95	55	94	85	90	95	99
Temperature—max.	86	85	85	85	86	93	85	65	72	80	84	88	81	89	88	93	89	92	86	82	74	70	79	85	80	89	81	85	81	74	80
Temperature—min..	60	56	63	67	64	58	54	41	46	56	54	53	52	58	52	65	66	66	62	60	57	55	56	57	62	62	62	68	58	49	52

AUGUST.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
Rainfall	...	.06	.07	T	....	....	....	....	.64	....	....	....	....	....	T	....	....	....	....	....	....	1.92	.74	....	.05	....	1.35	T	....	.1	....
Rel. hum. 7:00 a. m..	84	81	74	69	99	80	67	81	71	99	78	84	80	85	69	90	85	60	88	72	84	85	95	95	81	95	99	99	84	94	76
Temperature—max.	85	87	85	85	80	82	89	94	93	85	88	91	94	84	84	94	81	71	77	84	85	93	71	84	84	87	94	74	79	83	68
Temperature—min ..	61	56	63	57	60	55	65	71	67	60	55	58	62	57	62	64	51	52	48	50	59	66	63	59	67	67	65	57	50	52	44

SEPTEMBER.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
Rainfall	....	....	....	....	.32	....	....	....	....	....	....	....	.52	....	.96	....	....	....	....	1.32	....	.66	....	....	....	....	....	....	....	....	....	....
Rel. hum. 7:00 a. m .	68	89	82	65	95	85	67	61	95	82	82	81	94	78	87	95	95	76	74	66	74	82	85	79	94	65	77	66	79	99	....
Temperature—max.	77	78	89	89	70	78	67	78	86	92	93	87	78	81	98	87	93	92	90	88	88	88	65	72	78	66	65	66	55	60	....
Temperature—min..	51	58	57	57	57	45	48	61	66	72	62	60	58	59	62	64	67	68	73	64	63	26	42	48	46	38	41	37	30	31	....

We have followed Saccardo (Sylloge Fungorum) in the arrangement of orders, genera and species, and in most cases have used the synonomy given by him.

USTILAGINEAE.

Ustilago hypodytes (Schlecth.) Fr.
Very abundant. On Stipa spartea.
U. tritici (Pers.) Jensen.
Not uncommon and was frequent in 1894 on Triticum vulgare.
U. hordei (Pers.) Kellerman and Swingle.
Common on Hordeum vulgare.
U. nuda (Jensen) Kellerman and Swingle.
Scarce on Hordeum vulgare.
U. avenae (Pers.) Jensen.
Not uncommon on Avena sativa.
U. segetum (Bull) Dittm.
Common on Arrhenatherum avenaceum.
U. neglecta Niessl.
Abundant on Setaria glauca.
U. Rabenhorstiana Kuhn.
On Panicum sanguinale abundant.
U. maydis (D. C.) Corda.
Abundant on Zea mays.
U. pustulata Tracy & Earle.
Locally abundant in one place, first time observed on Panicum proliferum.
Tilletia-striæformis (Westend.) Magnus.
Not abundant on Phleum pratense.
T. foetens (B. & C.) Trelease.
Not observed in 1895.
Schizonella melanogramma (D. C.) Schroet.
Abundant in May, Moingona.
Sorosporium syntherismæ (Schw.) Farlow.
Abundant on Panicum capillare.
Urocystis Agropyri (Preuss) Schroet.
Abundant in June and early July on Elymus Canadensis.

UREDINEÆ.

Uromyces Polygoni (Pers.) Fuckel.
Abundant August and September on Polygonum aviculare and P. erectum.

U. Trifolii (Hedw.) Lev.

Abundant in September on Trifolium pratense. This fungus has been increasing in severity, large patches of second crop of clover being affected.

U. appendiculatus (Pers.) Link.

Abundant on Strophostyles angulosa, but not observed here on Phaseolus vulgaris. At Indianola it was, however, destructive to the cultivated bean.

U. Euphorbiæ Cooke & Peck.

Abundant in August and July on Euphorbia maculata and E. Preslii.

Melampsora farinosa (Pers.) Schroet.

Abundant on Salix, August and September.

M. Populina (Jacq.) Lev.

Abundant on Populus monilifera, August and September.

Puccinia Helianthi Schw.

Abundant on Helianthus tuberosus and H. grosse-serratus July, August and September. In August especially destructive to cultivated Helianthus annuus.

P. Convolvuli (Pers.) Cast.

Abundant on Convolvulus sepium July, August and September.

Gymnosporangium macropus Link.

Teleuto stage on Juniperus Virginiana not as abundant as in 1894; nor was the æcidium (Roestelia pyrata) so abundant on Pyrus Iowensis. Locally, however, in Madison county it seriously affected the leaves, stems and fruit of the wild crab. May was unfavorable for the germination and development of the teleutospores.

Phragmidium subcorticium (Schrank.) Winter.

Abundant on the leaves of the cultivated rose, as Madam Charles, Frederick Worth, August and September.

Aecidium Grossulariæ Schum.

Not so common as in 1894 on Ribes Grossulariae, R. gracile.

Uredo Cæoma-nitens Schw.

(C. interstitiale, Schlecht and is supposed to be connected with Puccinia Peckiana.) Abundant on Rubus villosus; large patches of native blackberry destroyed; seriously affecting cultivated blackberry locally. It was also observed in Story, Polk, Louisa and Henry counties.

P. Graminis Pers.

Not common on Triticum vulgare, Avena sativa and Hordeum jubatum. June and July. Aecidium abundant on Berberis vulgaris May-June. Very destructive on fall sown oats and wheat. August and September; also Hordeum jubatum.

P. coronata Corda.

Not common on Avena sativa, June and July. Abundant August and September. Klebahn has recently separated another species out of what has passed as this, until further work in this country, the species is used here as it is by American authors generally.

P. rubigo-vera (D. C.) Wint.

Not common, on wheat June and July. Abundant on fall sown wheat, Hordeum jubatum, August and September. Squirrel-tail grass is held in check by this fungus.

P. Sorghi Schw.

Abundant August and September on Zea Mays.

P. emaculata Schw.

Abundant on Panicum capillare August and September.

P. Andropogonis Schw.

Not abundant on Andropogon furcatus. A. scoparius, August and September.

P. Xanthii Schw.

Abundant on Xanthium Canadense, July, August and September. In low grounds destroyed a large number of plants.

PERONOSPORACEÆ.

Cystopus candidus (Pers.). Lev.

Abundant early in the season on Lepidium intermedium, L. Virginicum, Capsella bursa-pastoris. Later, oospores abundant in infloresence of Rhaphanus sativa.

C. Tragopogonis (Pers.) Schroet.

Locally abundant in June and early July.

C. Portulacæ (D. C.) Lev.

Abundant on Portulaca oleracea from the middle of June to the first of September. Oospores abundant.

C. Bliti (Biv.) De By.

Abundant July, August and September on Amarantus albus, A. retroflexus. More severe on the latter species.

Sclerospora graminicola (Sacc.) Schroet.

Abundant during the latter part of May till middle of June,

destroying large numbers of young plants of Setaria viridis. In whole patches it prevented the maturing of seeds.

Plasmopara Viticola (B. and C.) B. and DeT.

Abundant. Destructive to cultivated grape (Vitis Labrusca), affecting leaf, stem and fruit. Also affecting the growing of young shoots of Vitis riparia, in some cases killing the young shoots.

P. Halstedii (Farlow) B. and DeT.

Not common, on Helianthus annuus, H. tuberosus, Silphium laciniatum, Xanthium Canadense, Centaurea.

Bremia Lactucæ Regel.

Not observed although abundant in 1893.

Peronosposa Viciæ (Berk.) DeBy.

Abundant in latter part of May and early June on Vicia Americana.

P. Arthuri Farlow.

Abundant on Oenothera biennis.

P. parasitica (Pers.) DeBy.

Abundant on leaves and stems of Lepidium intermedia, L. Virginicum, killing the affected plants. On leaves of Capsella bursa pastoris not destructive. Brassica nigra, B. campestris, Raphanus sativa, Draba Caroliniana. Sisymbrium officinale seriously affected.

P. Potentillæ DeBy.

Not found in 1895. Local in 1894.

P. effusa (Grev) Rabenh.

Abundant on Chenopodium album in May and June.

P. Euphorbiæ Fuck.

Locally abundant on Euphorbia Preslii and E. maculata.

P. alta Fuckel.

Abundant on Plantago major.

PERISPORIACEAE.

Podosphæra Oxyacanthæ (D. C.) De By.

Abundant on cultivated (Prunus Cerasus) and P. pumila. Not common on P. Americana; also observed on young shoots of Crataegos punctata, and C. mollis; July, August and September.

Spærotheca Mali (Duby) Burrill.

Common on suckers of Pyrus Malus and young shoots of P. toringo in nursery, June, July and early August.

S. Mors-uvae (Schw.) Berk & Curt.

Abundant on Ribes Grossulariae, R. floridum, June, July; leaves, stem and fruit.

Phyllactinia suffulta (Reb.), Sacc.

Abundant on Fraxinus Americana, August and September.

Uncinula necator (Schw.) Burrill.

Common on Vitis Labrusca, Concord, Worden and especially Roger hybrids (Agawam).

Microsphæra Alni (D. C.) Wint.

Abundant on Syringa vulgaris, S. Persica, Lonicera, August and September. Abundant latter part of August and September.

Erysiphe Cichoracearum D. C.

Very abundant on Helianthus annuus, H. tuberosus. Not so common on H. grosseserratus. Abundant on Ambrosia artemisiaefolia, A. trifida, Artemisia, Ludoviciana; generally attacked by Cicinnobulus Cesatii. Abundant on Verbena stricta; less common on V. hastata.

E. communis (Wallr.) Schl.

Abundant on Rannuculus abortivus and Amphicarpæa monoica.

SPHÆRIACEÆ.

Physalospora Bidwellii (Ell.) Sacc.

None observed in 1895.

DOTHIDEACEÆ.

Phyllachora Graminis (Pers.) Fuck.

Common on Muhlenbergia Mexicana, Elymus Canadensis, Panicum scoparium Asprella hystrix.

P. Trifolii (Pers.) Fuck.

Abundant, conditial stage on Trifolium pratense, September.

Plowrightia morbosa (Schw.) Sacc.

Abundant on Prunus domestica, P. Padus, and wild P. Americana, P. Virginiana and Japan plum.

GYMNOASACEÆ.

Exoascus communis Sadebeck.

Rare on Prunus Americana in 1895; abundant on Prunus Cerasus and P. domestica. Nursery stock defoliated in August. Not as severe on P. Americana. Also occurred on P. Mahaleb and P. avium.

HYPHOMYCETEÆ-MUCEDINEÆ.

Monilia fructigena Pers.

Abundant late in season on fruit of Prunus Americana.

DEMATIACEÆ.

Cladosporium carpophilum Thum.

Rare on Prunus Americana, but abundant on Cratægus mollis late in August and September.

Helminthosporium Graminum Rabh.

Not common on Hordeum vulgare in July.

Cercospora Resedæ Fuck.

Abundant on Reseda odorata in August and September.

C. Beticola Sacc.

Abundant on Beta vulgaris. (Sugar and mangel beets). September. In some cases leaves completely covered with cinereous spots.

C. angulata Winter.

Abundant on Ribes rubrum, shrubs nearly defoliated latter part of July and early August. Fungus appeared early in May.

SPHÆROPSIDEÆ SPHÆROIDACEÆ.

Septoria Rubi West.

Abundant on Rubus odoratus, R. canadensis August and September.

Septoria Ribis Desm.

Abundant on Ribes nigrum, June and September.

Melanconiaceæ.

Cylindrosporium Padi Karst.

Abundant on Cherry.

Marsonia Juglandis Sacc.

Trees of Juglans cinerea nearly defoliated by middle of August. Not so severe on Juglans nigra.

M. Martini Sacc.

Abundant on Quercus robur; majority of leaves affected; also occurred on Q. macrocarpa.

BACTERIACÆ.

Bacillus amylovorus (Burrill) Trev.

Blight more severe than in 1894. Pyrus Malus, P. prunifolia, P. Sinensis, P. communis and P. Iowensis especially severe on the following varieties of P. Malus: Yellow Transparent apple, Red Queen-Lead, Arabskoe Antonovka, Thaler, Oldenburg. It seems, also, to have been severe in other parts of the state. Fruiting orchards less affected than nursery stock. It would seem that the condition of the soil may influence the

severity of the disease. We should also observe that flowers are occasionally affected, but not so severe as in 1894. The disease gradually subsided by the middle of July and early August.

B. Sorghi W. A. Kellerman.

Not severe. It occurred on Andropogon Sorghum var Halepense and A. Sorghum (Sorghum).

B. cloaceæ (Jordan).

On Zea mays; not abundant.

B. campestris Pammel.

Not observed in 1895.

SOME ANATOMICAL STUDIES OF THE LEAVES OF SPOROBULUS AND PANICUM.

EMMA SIRRINE AND EMMA PAMMEL.

Numerous writers have called attention to the value of anatomical studies for diagnostic purposes in the recognition of Phaenogams. We may note in this connection the paper by Pfister[1], who has made a comparative study of the leaves of some palms.

The author considers anatomical characters of value because so many palms are collected without flower or fruit. Bertrand[2] in a general paper considers the characters and important points to be observed in making anatomical studies of this kind. He notes that we must not lose sight of: 1. Inequalities in the grouping of subdivisions with the association of higher groups. 2. The paucity of material of certain forms, many intermediate species having disappeared in the lapse of time. These objections hold with equal truth to the characters now used in the classification of Phaenogams. He states that there are good differential characters in fibro vascular bundle found in Gymnosperms, vascular cryptogams and Phaenogams, but the arrangement of the fibro-vascular bundle is of less value. For the families such characters as the veins of leaf; development of stomata; secretion reservoirs; arrangement of inner phloem; for species the cuticle and trichomes are of value in diagnosis.

[1]Beitraege zur verleichenden Anatomie der Sabaleen Blartter. Inaugural Diss. 2 plates, Hofer and Burger (1892) Abst. Bot. Centralblatt, LI, p. 300.

[2]Des caracteres que l'anatomine peut founir a classification des vegetaux, pp. 54. Antun (Dejussieu) 1891, Abst. Bot. Centrablatt Vol. L. p. 375.

Priemer[3] states that peculiar hairs, epidermal cells, crystals cystoliths are of value for diagnostic purposes in the order Ulmaceae.

Bordet[4] has made some anatomical studies of the genus Carex. He concludes that in this genus anatomical characters do not offer any material aid in the separation of species. Although some good characters are found in fibro-vascular bundles.

Mez, who has made an exhaustive study of cystoliths and anatomical characters found in the sub-family Cordieae of the order Borraginaceae, finds that hairs are very characteristic and are certainly valuable from a systematic standpoint. Nor should we omit in this connection the valuable paper by Solereder[5] on the value of the wood structure in dicotyledonous plants, Holle[6] who has made an exhaustive study of the order Saxifragaceae calls especial attention to the structure of pith cells of *Cunonieæ*, the characteristic wood cells in certain genera, and crystals in the tribe *Hydrangeae*.

K. Leist[7] who has likewise made a study of Saxifragaceae concludes that the species of this order offer characters which makes it easy to separate them into groups, but this grouping does not always conform to the present systematic position of its members. Nevertheless general harmony prevails between morphological and anatomical characters as to species.

Several other authors Christ[7], Thouvenin[8], Waldner[9] and Engler[10] have likewise studied this order with reference to different organs and parts.

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[3]Uber seine unter Lietung von Prof. Prantl ausgefuehrten untersuch ungen uber die Anatomine Ulmaceen. Bot. Centralblatt, Vol. L, p. 105.

[4]Recherches anatomiques sur le genere Carex (Revue generale de Botanique, Vol. III, 1891, p. 57-64. Abst. Bot. Centralblatt, Vol. LI, p. 116.

[5]Uber den systematischen Werth den Holzstructur bei den Dicotyledonen. R. Oldenbourg, Muenchen. 1885.

[6]Beitraege zur Anatomie der Saxifragaceen und deren Systematische Verwerthung. Bot. Centralblatt Vol. LIII. p. 33, 65, 97, 129, 161, 209.

[7]Beitraege der vergleichenden Anatomie der Saxifragaceen. Bot. Centralblatt Vol. XLIII. p. 100, 136, 161, 233, 281, 313, 345, 377.

[7]Beitraege zur vergleichenden Anatomie des Stengels der Caryophylleen und Saxifrageen. Diss. Marburg, 1887.

[8]Sur l'appareil de soutien dans les tiges des Saxifrages.

[9]Die Kaldruesen der Saxifrageen. Graz 1887.

[10]Monographie der Gattung Saxifraga. Breslau 1872.

Synopsis of North American Pines, based on leaf-anatomy. Bot. Gazette, XI, p. 256, 302; plate VIII.

Die Anatomie der Euphorbiaceen in ihrer Beziehung zum system derselben. Separate Eugler's Botamische Jahabucher, Vol. V, p. 334-421; plates VI and VII.

Mention should be made of the splendid work of Coulter and Rose on the anatomical characters found in the leaves of conifers and their value in the recognition of species. A subject referred to long ago by Dr. George Engelmann. The work of Pax on the anatomy of Euphorbiaceæ, Trecul and others on the stems of many plants.

It will not be necessary to give other references; the literature is quite extensive. More work should be done along this line. We should study the biological relations and the consequent peculiar anatomical structures of plants. It is a field full of interest. Theo. Holm has called attention to the value of this kind of work in studying our flora.

Ganong, in a recent paper with reference to biology and morphology (Present Problems in Anatomy, Morphology and Biology of Cactaceæ, Bot. Gazette, Vol. XX, p. 130), says: "As to the tissues, it is enough here to say that the characteristic *xerophilous* appearances are strong cuticle, thick epidermis, perfect cork, sunken stomata, collenchymatous hypoderma, deep palisade layers; great development of pith and cortex, which consists of large, round, splendidly pitted water-storing cells, often containing mucilage * * * ." The whole system conforms closely to the external form and follows its morphological changes. We notice this especially because the same thing holds true in other plants outside *Cactaceæ*, especially grasses. Great difference occurs between such plants as are habituated to humid climates and those occurring in a dry climate. This offers, indeed, a great field for investigation.

ANATOMICAL STUDY OF GRASSES.

Theo. Holm has done well in calling attention to some anatomical characters of North American Gramineae. In speaking of the studies which had been made he says: "The importance of studies of that kind was very clear; they not only furnished additional and often even more reliable systematic characters, but the extended study of anatomy into wider fields than ever before, until anatomy has become one of the most important modern lines of botanical science." He emphasizes the importance of internal structure, as it will give a striking illustration of the physiological life of the plant. It will not be necessary here to refer to earlier writers on the subject; suffice

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it to say here that Duval, Jouve[11], Hackel[12], Güntz[13], Samsöe, Lünd[14] and Beal[15] have made valuable contributions.

Theo. Holm[16] has studied Uniola latifólia, U. grácilis, U. nitida, U. paniculâta and U. Palmeri, Distichlis, Pleurogogon and Leersia.

From a study of some of the species of *Uniola* growing under widely different conditions, he concludes, that of the five species, the genus show anatomical structures by which they may be easily distinguished.

He says of the genus *Distichlis*, that, "Considered altogether, the anatomical structure of the leaf in the genus *Distichlis* is very uniform, and it does not seem possible to give any special characters by which either of the varieties or the supposed species *thalasica* and *prostata* may be distinguished from the species *maritima*; because we have seen that male and female specimens of this last show variations among themselves nearly equivalent with the differences in the two varieties and subspecies." Of *Pleuropogon*, he says: "Considering now these three species of *Pleuropogon* together, it is evident that they are, in spite of their great similarity, easily distinguished from each other" by certain anatomical characters taken from leaf blade.

THE GENUS SPOROBOLUS.

The species of the genus *Sporobolus* are nearly all western or southern. Those occurring in Iowa are characteristic western plants and well adapted to dry climate conditions. The following species of *Sporobolus* were studied: *Sporobolus heterolepis* Gray; *S. cryptandrus* Gray; *S. Hookeri*, *S. vaginæflorus*.

SPOROBOLUS HETEROLEPIS.

The epidermal cells (e) are rectangular in shape, with a strongly developed cuticle (c); they vary but little in size. The bulliform cells (b) occur between each mestome bundle (m), except between the last few at the tip of the leaf, where it is occupied by the streome (st.). The bulliform cells occur in four or five rows, a large central cell and three or four smaller cells

[11] Histotaxie des feuilles de Graminees.

[12] Monographia Festucarum Europaearum, 1882.

[13] Untersuchungen ueber die anatomische Structur der Gramineenblaetter, etc. Inaug. Dissert. Leipzig, 1886.

[14] Vejledning til at kjende Graesser i blomterlos Tilstand, Kjobenhavn, 1882.

[15] Grasses of North America for farmers and students.

[16] A study of some anatomical characters of N. America Gramineae. Bot. Gazette, Vol. xvi. p. 166, 217, 275.

on each side. The strongly involute character of the leaf is due to the bulliform cells.

The carene (c′) is occupied with one mestome bundle; this bundle is somewhat different than the others, as it is surrounded on the upper side by chlorophyll bearing parenchyma while the lower side contains stereome.

The mestome bundles on right and left of carene are entirely closed (i. e., entirely surrounded by chlorophyll bearing parenchyma). This species is provided with three different types of mestome bundles; the first occurs in carene; this has stereome on lower side in contact with leptome; the second, those which have stereome both on lower and upper side, in contact with leptome and hadrome; and third, those that are entirely closed. Those that are entirely closed occur alternate with those having stereome on upper and lower surface. As to the mestome bundles, there are, in this species, five on left side of the carene and seven on the right side. On the left, the leaf terminates with one closed mestome bundle. The right side of the leaf terminates with three mestome bundles. The mestome bundles, except those at the tip of the leaf, are separated from each other by the bulliform cells and three or four layers of colorless parenchyma. The uncolored parenchyma is more conspicuous near the median nerve, where it is quite strongly developed. In this species the mesophyll does not occur between the bundles but is found only in immediate contact with chlorophyll bearing parenchyma (c b p).

The uncolored parenchyma cells are in immediate contact with stereome. The mestome bundles are entirely closed and do not have leptome (l) and hadrome (h) so well developed as in the other bundles. The leptome in the open bundles (i. e., having stereome in contact with both leptome and hadrome) seem to be in two parts, there being a depression on upper side of leptome.

The stereome occurs on the upper side of all bundles, and also on the lower side of all bundles except those which are entirely closed.

Below the uncolored parenchyma connecting the mestome bundles we find the stereome. The stereome occupies a prominent place on the sides of the leaf, forming on the left two triangular groups of cells separated by two layers of uncolored parenchyma. On the right side three such groups occur between the last four mestome bundles.

The chlorophyll bearing parenchyma can be divided into two parts. First, large parenchyma cells surrounding the bundles; these consist of rather large cells somewhat roundish in shape; second, elongated cells in one or more rows around the first.

SPOROBULUS CRYPTANDRUS.

The epidermal cells in this species do not differ from those described for S. heterólepis. The bulliform cells (b) are somewhat larger than those in the first species, usually two or three quite large cells and two smaller on each side. One or two groups of bulliform cells occur between a large mestome bundle, and, as in S. heterólepis, these do not occur between the last two bundles.

The carene (c^1) has one mestome bundle (m) which is open on both sides. It is somewhat larger than other mestome bundles. The leptome (l) and hadrome (h) are separated from each other by thick-walled parenchyma (p^1); two rows of thick parenchyma occur around the leptome.

The mestome bundles are of three types: First, those open above and below; second, those open above only, and third, such as are entirely closed. Those of the third type are more numerous than others. One mestome bundle is entirely closed and at the side of the leaf, those of the third type alternate with those of the second and first types. The second type is more numerous than the first. Ten bundles occur on each side of the carene. The mestome bundles of the third type are usually found between two groups of bulliform cells. The chlorophyll bearing parenchyma (c. b. p.) is about as in S. heterolepis. The leptome in this species differs from leptome in S. heterolepis in not being depressed on the upper side.

The stereome (st) is found on the lower side of all bundles, and also upon the upper side of all bundles except those of the third type. The cells of the sterome are not so thick walled as in S. heterolepis.

The mesophyll consists of elongated cells in one or two rows around each mestome bundle. There seems to be mesophyll connecting the bundles beneath the unclosed parenchyma. The unclosed parenchyma is found in one or two rows around the bulliform cells in contact with the mesophyll.

SPOROBOLUS HOOKERI.

The epidermal cells (e) of this species are small, thick walled and uniform in size, they are more roundish than in

other species. The cuticle (c) and cell wall, are well developed in this species. The leaf is strongly involute on the upper surface and here we also find papillae.

The bulliform cells (b) are also much larger than in the other species, there being four to six in a row, sometimes one large central cell and sometimes two large central cells with two smaller bulliform cells on either side of the large ones.

The carene (c), in this species consists of five mestome bundles (m), three very small, a large central, and one medium in size. The leptome (l) and hadrome (h) are fully developed in the two large bundles. The hadrome is separated from the leptome by two layers of thick walled parenchyma. One small mestome bundle occurs on each side of the medium bundle.

The mestome bundles are all connected with each other by the mesophyll (m).

The mestome bundles number thirty-eight, eighteen on left and twenty on right side of carene (c). In this species three types of bundles occur: First, those open on both sides; second, those open above only; and third, those entirely closed. Those of the third type are of two sizes one very small, the other somewhat larger. The mestome bundles of the third type predominate. The sides of the leaf terminate with a closed bundle. In the mestome bundle of the second type the leptome and hadrome seem to be in immediate contact with each other, but in those of the first type they are separated by thick-walled parenchyma. The chlorophyll bearing parenchyma does not differ materially from that found in other species.

The stereome (st) is on the lower side of all the bundles and on the upper side of those of the first and second type. The leaf also terminates with irregular groups of stereome. The stereome is quite well developed in the carene where it occurs in large groups.

The mesophyll (mes) in this species connects the different mestome bundles and consists of both round and elongated cells.

The uncolored parenchyma is more strongly developed in this than in any of the other species of Sporobolus studied. It is prominent in the midrib, where it occupies the space above the five mestome bundles. It also occurs immediately below the bulliform cells and on the upper side of the mestome bundles

(m) of the second type connecting these bundles with the stereome.

SPOROBOLUS VAGINAEFLORUS.

In this species the epidermis (e) resembles that of other species except the cuticle (c) which is much more fully developed.

The bulliform cells (b) in this species differ much from those of other species, they are very irregular in outline, the cells ranging in number from eight to ten, and occur almost the entire length of the leaf except near the sides where we find the uncolored parenchyma (p).

The carene (c') consists of one mestome bundle which has stereome in contact with leptome (l). This is the only bundle which is open. On either side of this median bundle there are three or four small closed bundles. The leptome and hadrome (h) are separated by thick walled parenchyma. The mestome bundles number twelve, five to the left and six to the right of the carene. The bundles are of two types: first the median one which is open below and the second, closed; the bundles of this latter type are of two sizes, one very much smaller and the other nearly as large as that of the median nerve. The well developed leptome and hadrome in the median nerve and the larger bundles of the second type are characteristic. The smaller mestome bundles predominate, numbering nine in a leaf. The sterome occurs on upper and lower surface of the mestome bundles of the carene, and large sized mestome bundles of second type, but none are found in contact with smaller sized bundles.

The cells of the chlorophyll bearing parenchyma (c. b. p.) in this species are much smaller than the cells of the other species.

The uncolored parechyma (p) is found only at the edges of the leaf above the last two mestome bundles.

PANICUM.

The large genus Panicum is widely distributed in tropical and warmer countries with a goodly number in temperate climates. The representatives studied by us are common species in the Mississippi valley and southward. The three species, P. capillare L., P. proliferum L., and P. crus-galli L , grow in moist places or where there is considerable rainfall. The weedy P. capillare is perhaps an exception, as it is adapted to a wider range of climatic conditions, the structure of the leaf

plainly shows that it can adapt itself to different conditions of soil and moisture.

PANICUM CAPILLARE.

This species has a hairy appearance and is harsh to the touch. The epidermal cells (e) are large, the cuticle (c) and epidermal cell walls are thicker than in P. crus-galli and P. proliferum, but not so well developed as in the genus Sporobolus. The walls of the epidermal cells of the upper and lower surface of the leaf have small conical projections (c p). The end of the leaf terminates in a small thickened point; on the edges of leaf occurs a bundle of stereome (st).

The bulliform cells do not vary much from the epidermal cells, they are somewhat larger, however, and vary in number from three to five, the middle cell being the largest. The carene (c') has one mestome bundle (m) differing from those of secondary veins only in that it is larger, and being open on both upper and lower side. The mestome bundles are of three types: first, those which are open both above and below, second, those which are open below, and third, those which are closed. The leptome (l) is separated from hadrome (h) by thick walled parenchyma (p). In this species the arrangement of mestome bundles is irregular, the number varies from forty to forty-three bundles in one leaf. There are from twenty to twenty-two bundles on each side of the carene, and of these, three on each side are of the first type, three of the second type and the remaining of the third type. In the closed mestome bundles the leptome and hadrome are not so well developed as in those which are open. The stereome occurs on the upper and lower surface of all open mestome bundles, while in those which are closed it is found sometimes on the upper surface and sometimes on the lower surface, and sometimes it is entirely wanting. It consists of from two to four rows, bordering immediately on the chlorophyll bearing parenchyma (c b p). At the sides of the leaf well developed stereome occurs for the purpose of protection.

The mesophyll (mes) consists of elongated cells joining the chlorophyll bearing parenchyma. Between the mestome bundles surrounded by the mesophyll, we have colorless parenchyma.

PANICUM PROLIFERUM.

In this species the epidermal cells are much smaller than in P. capillare, and the conical projections (c p) are found more

strongly developed only on the upper surface of the leaf; they are much more numerous than in P. capillare, but not nearly so sharply defined. The cuticle (c) is not so strongly developed as in P. capillare.

The bulliform cells vary from two to five, usually consisting of one large or two large central cells. The leaf is not so strongly involute in this species, but the bulliform cells (b) extend farther down into the mesophyll (mes) than in P. capillare.

The carene (c') has one mestome bundle (m), which is open at the lower side. There are from forty to forty-five mestome bundles in the leaf, the median being the largest. On either side of the carene are five small mestome bundles entirely closed, then occurs a secondary bundle on each side resembling the carene, only much smaller. The leptome is separated from the hadrome in the carene by thick-walled parenchyma cells (p).

The mestome bundles are of two types; first, such as are open below, and second, those that are entirely closed. The closed are much more numerous than the open; only six or seven open in the whole leaf. The leptome (l) and hadrome (h) are not well developed in the small bundles.

The mesophyll consists of elongated and somewhat loosely arranged cells of variable size. One larger surrounds the chorophyll bearing (c b p) parenchyma cells and comes in contact with the stereome (st); the space between the mestome bundles and beneath the bulliform cells is also filled with them.

The stereome is found on the lower side of all bundles, in contact with the parenchyma and epidermis, and also on the upper surface of all the larger mestome bundles.

PANICUM CRUS GALLI.

The most obvious difference between P. crus-galli and P. capillare is that in this species the leaf is not involute; the epidermal cells (e) are large; the cell wall and cuticle (c) is not so strongly developed but conical projections are found on both surfaces of the leaf.

The carene has one mestome bundle (m). It differs from the other species studied in that the stereome is not in direct contract with the leptome (l) and hadrome (h) but is separated from them by two rows of thick walled parenchyma (p), while the leptome and hadrome are in direct contact with each other.

The mestome bundles are of two types; first, those that resemble the open bundles of other species, only that in this case they are surrounded by thick walled parenchyma outside of which, on two sides occur the chlorophyll bearing parenchyma cells (c b p); second, those that are entirely closed.

The mestome bundles are differently arranged in this species, a small mestome bundle occurs beneath the bulliform cells, this bundle is smaller than the one occurring between the bulliform cells, but is of the same type. Surrounding the bundles of the first type are small chlorophyll bearing cells and more numerous than in the other species studied. The chlorophyll bearing parenchyma cells surrounding those of the second type are larger than those of the first type, but not as large as those of the other type. In this species the leptome and hadrome are in immediate contact while thick walled parenchyma cells surround both.

The stereome is found on the upper and lower surface of all mestome bundles of the first type and separated from leptome and hadrome by thick walled parenchyma. Stereome does not occur around the mestome bundles beneath the bulliform cells. The mestome bundles between the bulliform cells are always closed below and sometimes entirely so.

The mesophyll consists of both elongated and round cells bordering on the chlorophyll bearing parenchyma.

COMPARISON.

A comparison of the two genera shows that in the genus Sporobolus the cuticle and cell walls are much more strongly developed than in the genus Panicum.

The mestome bundles in Panicum are more numerous than in Sporobolus. The epidermal cells in Sporobolus are uniform in size, in Panicum variations occur in different species, while in P. crus-galli, the epidermal cells on both sides of the median nerve are smaller than elsewhere on the leaf.

The bulliform cells are larger and more numerous in Sporobolus than in Panicum.

CONCLUSIONS.

We feel safe in concluding from our study of these genera that the anatomical characters are marked and constant enough to readily enable one to distinguish the species, and along with the work of others it shows that anatomical characters may be used as a basis for the separation of genera and some species.

EXPLANATION OF PLATE VI.

In all figures the same letter is used for the same character — c, cuticle; e, epidermis; st, stereome; m, mestome; c b p, chlorophyll bearing parenchyma; b, bulliform cells; mes, mesophyll; h, hadrome; l, leptome; c p, conical projections. All figures drawn with camera to the same scale. General drawings $\frac{1}{2}$ inch objective; detailed drawings $\frac{1}{4}$ inch objective.

Figures	I, II, III,	*Sporobolus*	*heterolepis.*
"	IV, V,	"	*vaginæflorus.*
"	VI,	"	*Hookeri.*
"	VII, VIII,	"	*cryptandrus.*
"	IX, X,	*Panicum*	*proliferum.*
"	XI, XII,	"	*capillare.*
"	XIII, XIV,	"	*Crus-galli.*

A COMPARATIVE STUDY OF THE SPORES OF NORTH AMERICAN FERNS.

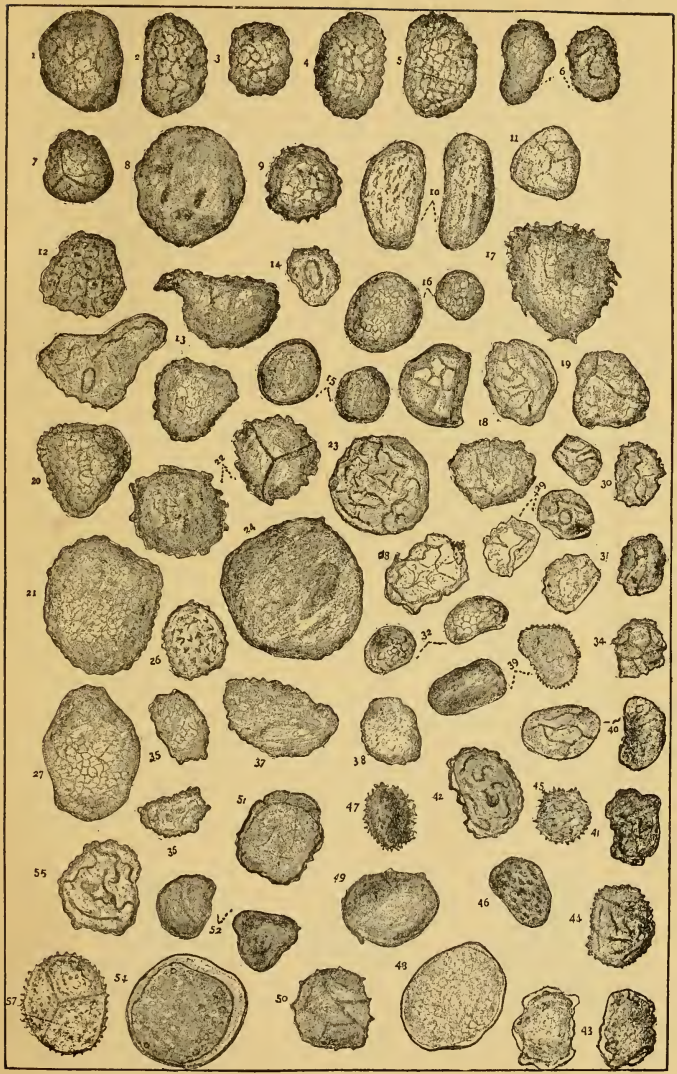
BY C. B. WEAVER.

Ferns have been objects of interest to botanists and cultivators; they have therefore been studied more than many of the flowering plants. Their simple structure and the apparently well defined limitation of species has rendered them easier for purposes of study than many of the groups of Phaenogams.

The purpose of this paper is to make a small contribution toward our knowledge concerning the spore characters of the different genera and species of North American ferns.

The measurements of a few spores are here given:

NAME.	Locality.	Length and breadth of largest spore.	Length and breadth of smallest spore.	Length and breadth of medium sized spore.	DESCRIPTION OF THE SPORES.
Polypodium vulgare	Mo	72.6—49.5	56.1—39.6	69.3—46.2	Spores large, smooth.
Polypodium incanum	Mo	49.5—33	39.6—29.7	46.2—26.4	Spores smooth on surface.
Notholaena ferruginea	Mass	85.8—79.2	66 —66	69.3—66	Spores large.
Adiantum capillus-Veneris	Ark	52.8—49.5	36.6—36.3	42.9—39 6	Medium size, somewhat irregular, slightly smooth.
Adiantum pedatum	Ark	49.5—46.2	42 9—36.3	46.2—42.9	Same as A. capillus-Veneris.
Pteris aquilina	Del	36 3—33	29.7—23.1	36.3—33	Spores small, spiny, rough, uniform in size.
Cheilanthes Alabamensis	Tenn	54.1—46.2	33 —33	49 5—46 2	
Cheilanthes lanuginosa	Iowa	62.7—42.9	52.8—42.8	59.4—49.5	Spores medium size, slightly roughened.
Chellanthes tomentosa	Tenn	45 —54	33 —42	33 —45	
Pellaea atropurpurea	Iowa	82.5—75 9	66 —62.7	66 —69.3	Spores large, spiny and slightly roughened.
Woodwardia radicans	Cal	69 6—52.8	49 5—39.6	62.7—52.8	Spores oblong, large, not particularly characteristic.
Woodwardia angustifolla	N. Y., L. I	39 —51	33 —39	36 —42	Similar to W. radicans.
Asplenium trichomanes	Wis	33 —26.4	26.4—23.1	33 —23.1	Spores small; membranous structure not so prominent as in some other species.
Asplenium angustifollum	Mo	33 —48	24 —36	30 —42	Spores vary in size, not very rough, reticulated.
Asplenium Filix-foemina	Iowa	42 9—29.7	33 —23.1	33 —25.4	Spores average size, elliptical with rough surface.
Camptosons rhizophyllus	Mo	36.3—29.7	33 —29.7	46.2—29.7	Spores medium size, somewhat roughened.
Phegopteris Dryopteris	Wis	42 —27	36 —18	33 —24	Spores rough.
Phegopteris hexagonoptera	N. Y	57 —42	27 —21	54 —39	Spores similar to *P. Dryopteris* quite rough.
Aspidium Noveboracense	Conn	49.5—33	42.9—33	49.5—29.7	Spores not characteristic, rough.
Aspidium Thelypteris		56.1—39.6	49.5—36.3	56.1—33	Spores medium size, quite rough.
Aspidium marginale		46.2—29.7	29.7—29.7	39.6—29.7	
Aspidium Lonchitis	Utah	36.6—29.7	33 —23.1	33 —33	Spores not large, usually elliptical, some round.
Cystopteris bulbifera	Minn	39.6—29.7	33 —26.4	33 —26.4	Spores medium size, very spiny.
Cystopteris fragilis	Mex	48 —36	39 —33	42 —33	Spores not as spiny as *C. bulbifera*.
Onoclea sensibilis	Iowa	72.6—59.4	49.5—46.2		Spores large, very smooth, nearly round.
Onoclea Struthiopteris	Wis	57 — 39	39 —39	54 —45	Spores similar to O. sensibilis, not so large.
Woodsia Ilvensis	Wis	59 4—46.2	42.9—33	49.5—46.2	
Schizaea pusilla	N. J	105.6—59.3	63.3—62.7	89.1—62.8	Spores very large, smooth surface, remarkable for size.
Osmunda regalis	Mo	66 —66	46.2—46.2	62.7—59.4	Spores rough, resemble S. pusilla in structure, but much smaller.
Osmunda Claytoniana	Iowa	48 —30	36 —36	45 —27	Spores similar to O. regalis, not so large.



C. B. Weaver, Del.

EXPLANATION OF PLATE.

No.
1. *Acrostichum aureum.*
2. *Polypodium vulgare.*
3. *Polypodium falcatum.*
4. *Polypodium Californicum.*
5. *Polypodium pectinatum.*
6. *Polypodium aureum.*
7. *Gymnogramme triangularis.*
8. *Notholæna ferruginea.*
9. *Notholæna nivea.*
10. *Vittaria lineata.*
11. *Adiantum capillus-Veneris.*
12. *Pteris longifolia.*
13. *Pteris cretica.*
14. *Pteris longifolia.*
15. *Cheilanthes microphylla.*
16. *Cheilanthes Alabamensis.*
17. *Cheilanthes viscida.*
18. *Cheilanthes lanuginosa.*
19. *Cryptogramme acrostichoides.*
20. *Pellaea gracilis.*
21. *Pellaea atropurpurea.*
22. *Pellaea andromedæfolia.*
23. *Pellaea ternifolia.*
24. *Ceratopteris thalictroides.*
25. *Lomaria spicant.*
26. *Blechnum serrulatum.*
27. *Woodwardia radicans.*
28. *Asplenium pinnatifidum.*
29. *Asplenium trichomanes.*
30. *Asplenium firmum.*
31. *Asplenium Thelypteroides.*
32. *Asplenium Filix-fœmina.*
33. *Scolopendrium vulgare.*
34. *Camptosorus rhizophyllus.*
35. *Phegopteris calcarea.*
36. *Phegopteris Dryopteris.*
37. *Phegopteris Polypodioides.*
38. *Phegopteris alpestris.*
39. *Aspidium spinulosum.*
40. *Aspidium Oreopteris.*
41. *Aspidium Noveboracense.*
42. *Aspidium Thelypteris.*
43. *Aspidium acrostichoides.*
44. *Aspidium unitum.*
45. *Aspidium Lonchitis.*
46. *Nephrolepis exaltata.*
47. *Cystopteris bulbifera.*
48. *Onocloa sensibilis.*
49. *Woodsia obtusa.*
50. *Woodsia Ilvensis.*
51. *Woodsia glabella.*
52. *Dicksonia punctilobula.*
53. *Trichomanes Petersii.*
54. *Lygodium palmatum.*
55. *Aneimia adiantifolia.*
56. *Aneimia Mexicana.*
57. *Osmunda cinnamomea.*
58. *Osmunda regalis.*
59. *Schizæa pusilla.*

These tables show that there are differences with respect to size and character of species; in some genera species show marked differences in size of spores. Schizaea pusilla, the smallest of our ferns, has the largest spores of any species examined. Onoclea Struthiopteris has relatively small spores.

Fig. 56. Spores of ferns, Aneimia Mexicana.

Fig. 58. Osmunda regalis.

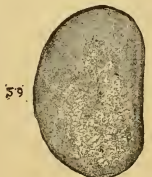


Fig. 59. Schizola pusilla.

INOCULATION EXPERIMENTS WITH GYMNOSPORANGIUM MACROPUS LK.

BY F. C. STEWART AND G. W. CARVER.

The family of true rusts, Uredineæ, is very interesting to the mycologist and important to the agriculturist. It contains about twenty-seven genera and a multitude of species, all of which are strict parasites, living within the tissues of their hosts. Several of the species produce destructive diseases in cultivated plants; as examples note the rust of wheat, oats and other grasses (*Puccinia graminis*, Pers.), blackberry rust (*Cœoma luminatum*, Schw.), and carnation rust (*Uromyces caryophyllinus* [Schrank], Schrœter). Thus far all attempts to cultivate the rusts upon artificial media have failed. Consequently the life histories of some species are imperfectly known. The determination of the life histories of some species is made still more difficult because of the fact that they do not complete their development upon a single species of host-plant, but inhabit different species at different stages in their development. The life history of the common wheat rust, Puccinia graminis, so frequently used to illustrate this peculiarity of rusts, is so familiar to readers of botanical literature that it is unnecessary to repeat it here. It is sufficient to state that wheat rust has three stages, two of which are found upon the wheat or some other grass plant and upon the common barberry (*Berberis*).

The species of Gymnosporangium belong to this class of pleomorphic rusts. There are two forms, representing two stages in the development of the fungus. Until about ten years ago these two forms were supposed to be distinct species and were given separate names. The Gymnosporangium form (considered to be the higher form) inhabits, exclusively, species of the Cupressineæ, a group of the family of cone bearing trees, Coniferæ. The other form has received the name

Rœstelia. It is found on the apple and allied plants belonging to the tribe Pomeæ, of the family Rosaceæ.

In the United States there are nine species of Gymnosporangium. Chiefly through the investigations of Doctors Farlow and Thaxter, all of them have been connected with their corresponding species of Rœstelia.

Gymnosporangium macropus, Lk., the particular species under consideration, is confined exclusively to the Red cedar, Juniperus Virginiana, L. Its Rœstelia form is known as *Rœstelia pirata*, Thax., and is found on cultivated apple (*Pirus malus*, L.), wild crab (*Pirus coronaria*, L.) and Juneberry (*Amelanchier*). The Gymnosporangium may be found in the autumn upon the twigs of Red cedar, where it appears in the form of small brown balls about the size of peas. In May of the following spring these balls enlarge and during rainy weather put out several orange-colored gelatinous horns. At this time the balls are very conspicuous objects and are universally known as "Cedar apples." The gelatinous horns contain numerous two-celled spores on long pedicels. The spores germinate *in situ* each one producing several minute secondary spores which are readily carried by the wind. When these secondary spores chance to fall upon leaves of apples or other suitable plant, they germinate and enter the tissues. In about three weeks, small yellow spots appear on the upper surface of the apple leaf. This is the Rœstelia, and when it is mature the spots will be one-fourth to one-half inch in diameter, yellow above and with tooth like projections beneath. Within the projections are formed round one-celled spores (æcidiospores) which may be carried to a cedar where they will germinate and repeat the life cycle.

The connection of *Gymnosporangium macropus* with *Rœstelia pirata* has been established beyond question by Dr. Thaxter[1]. The inoculation experiments here reported were not undertaken for the purpose of obtaining further information concerning the relationship existing between the two forms of the fungus, but rather to ascertain why the cultivated apple in central Iowa should be free from Rœstelia. Although the field has been thoroughly canvassed nearly every season during the past twenty-five years, no species of Rœstelia has ever been taken on any variety of cultivated apple in the

[1]On certain cultures of *Gymnosporangium* with notes on their *Roestel iae*. Am. Acad. Arts and Sciences, 1886, p. 259.

vicinity of Ames, Iowa.[1a] More than this, repeated efforts to artificially inoculate various varieties of cultivated apples with *Gymnosporangium macropus* have failed. In the spring of 1886 Dr. Halsted[2] inoculated *G. macropus* on two varieties of cultivated apple (Rawles' Janet and Tallman Sweet), wild crab *Pirus coronaria*[3], pear, mountain ash, *Pirus semipinnata*, several species of hawthorn and two forms of Juneberry on the grounds of the Iowa Agricultural College, Ames, Iowa. In no case did Rœstelia appear on the cultivated apples. He says[4]: "The individual experiments numbered among the hundreds, and in every case there was a perfect failure of the Gymnosporangium to grow except with the crab apple, where the inoculation was most emphatic." Further inoculations were made the following season, 1887. He says[5]: "During the present season cultural experiments with the native cedar have been carried out by special students. It is an easy matter to inoculate the wild crab with this, but only failures have attended tests upon other plants." In 1893 Prof. L. H. Pammel[6] made some inoculation experiments at Ames. A tree of the variety Tetofsky had been top worked with Fluke crab, which is an improved variety of Pirus coronaria; *G. macropus* was inoculated upon both parts of the tree on the same day, with the same cedar apple. In due course of time, Rœstelia appeared in abundance upon the Fluke crab portion of the tree but not a single leaf of the Tetofsky portion was affected. Inoculations were also made upon pear, Japan quince (*Cydonia Japonica*), cultivated apple and shadbush (*Amelanchier alnifolia*), but these all proved failures.

The above is, in brief, the history of the experiments at Ames previous to 1894. It appears to be well established, that at Ames, Iowa, the cultivated apple is wholly exempt from the *Rœstelia* disease which is very abundant and destructive in New England and in some of the southern states. The Red cedar does not grow spontaneously in central Iowa, but it is

[1a] Professor Pammel writes that he has never known or heard of *Roestelia* on any cultivated variety of apple in Iowa.

[2] Bulletin of the Iowa Agricultural College, from the Botanical department, November, 1886, pp. 59-64.

[3] Bailey considers the wild *Pirus* of Iowa to be specifically distinct from *P. coronaria* He has named it *Pirus Iowensis*. See L. H. Bailey's Notes from a Garden Herbarium VI; The Soulard crab and its rise. The American Garden, Vol. XII, p. 469.

[4] *l. c.*, p. 63.

[5] Bull. from the Bot. Dept. of the Iowa Agricultural College, February, 1888, p. 91.

[6] Diseases of foliage and fruit. Report of Iowa State Hort. Soc., Vol. XXVIII, 1893, p. 470.

frequently planted. There are several specimens in different parts of the Agricultural college grounds, some of them standing in close proximity to apple trees. *Gymnosporangium macropus* is fairly abundant, the amount varying according to the nature of the season as regards moisture. It is usually sufficiently abundant to thoroughly inoculate the wild crab trees. There is only one species of *Gymnosporangium* and only one species of *Ræstelia* at Ames. A second species of *Gymnosporangium*, *G. globosum*, Farl., has been found but once by Professor Pammel[7]. This species occurs in Wisconsin as indicated by Professor Trelease[8], and may be more common in eastern Iowa. It has not, however, been found since and Professor Pammel writes us that it may have been a chance introduction from material sent to Dr. Halsted. So far as we know, only one species of *Ræstelia* has been found at Ames. This tends to simplify matters considerably. Were it not for the fact that *Pirus coronaria* is so generally affected with *Ræstelia* and so easily inoculated artificially, we would at once conclude that the immunity of the cultivated apple is due to the climatic conditions in Iowa being unfavorable to the growth of *Ræstelia*. It is well known that the range of some fungi is limited by slight differences in climate; for example, the potato-blight fungus, *Phytophthora infestans*, De By., which causes great losses in some parts of the United States, has, I believe, never been collected in the state of Iowa. The climate there is too dry for it.

Another way to account for the facts is to suppose that certain varieties of apples are not susceptible to the disease and that only non-susceptible varieties are grown at Ames. This theory comes nearest to accounting for all the facts. There are two chief objections to it. *First*, the college orchard contains a large number of varieties and it is a remarkable circumstance that they should all be *Ræstelia*—resistant. However, it should be noted that most of them are Russian varieties; *second*, as a case of varietal differences in susceptibility to fungus attacks, it is unparalleled.

In the spring of 1894 we started some inoculation experiments at Ames. *Pirus coronaria* eleven varieties of cultivated apples and the previously mentioned Tetofsky tree top-worked with Fluke crab, were inoculated with the native *G. macropus*

[7]Journal of Mycology, Vol. VII., p. 102.

[8]A Preliminary List of the Parasitic Fungi of Wisconsin, p. 29.

and with *G. macropus* from Cambridge, Mass., by Mr. B. M. Duggar. All were complete failures. The spring and summer were unusually dry. This probably accounts for the failures with Fluke crab and wild crab. Natural cultures of *Rœstelia* on wild crab were rare.

In the spring of 1895 one of us being on Long Island, N. Y., and the other at Ames, Iowa, we again undertook some experiments with *G. macropus*. We will speak first of the experiments on Long Island. They were conducted in the nursery of Isaac Hicks & Son at Westbury, N. Y. On May 18th, four varieties were inoculated with New York *G. macropus*—Yellow Transparent, Red Astrachan, Ben Davis and Red Pippin. The first three were two-year-old nursery trees; the last was a large tree. Many leaves on one tree of each variety were smeared, both sides, with the gelatinous spore-masses of *G. macropus*. The results were as follows: Yellow Transparent showed no signs, whatever, of *Rœstelia*. Both Red Astrachan and Ben Davis showed yellow spots which appeared like the beginning of *Rœstelia*, but none of them developed. Red Pippin produced the *Rœstelia*, but the spores did not mature properly and the fungus presented a stunted appearance. On May 24th, six varieties were inoculated with Iowa *G. macropus*—Yellow Transparent, Red Astrachan, Ben Davis, Red Pippin, Maiden's Blush and Wealthy. All were two-year-old nursery trees except the Red Pippin. One tree of each variety was inoculated as before. The results were as follows: Yellow Transparent and Red Pippin showed no signs of *Rœstelia*. Red Astrachan and Ben Davis started *Rœstelia* spots which never matured. Maiden's Blush and Wealthy developed numerous *Rœstelia* spots and matured the aecidiospores thoroughly. As no bags were used to cover the inoculated leaves, it can not be said positively that the *Rœstelia* on Maiden's Blush and Wealthy resulted from the Iowa *G. macropus*, but the conditions were such as to warrant the above conclusions. In the case of Red Pippin there can be no doubt as to which inoculation produced the *Rœstelia*. A large tree which stood at considerable distance from the other inoculated trees, was inoculated on one side with New York *G. macropus* and on the other side with Iowa *G. macropus*. The leaves of the branch inoculated with New York *G. macropus*, and a few other leaves in the immediate neighborhood, produced *Rœstelia* while the remainder of the tree showed not a *Rœstelia* spot. It is also

practically certain that all of the *Ræstelia* found in connection with these experiments was the *Ræstelia* of *G. macropus*. Careful search was made in Mr. Hicks' nursery and in orchards at Floral park and Queens, Long Island, but no *Ræstelia* on cultivated apple was found anywhere on Long Island during the season of 1895, except at Flushing, where a few specimens were taken by Mr. F. A. Sirrine.

The following table presents, in a condensed form, the results of the experiments on Long Island:

Variety.	Material Used.*	Condition June 15.	Condition June 29.	Condition Aug. 21.
Yellow Transparent,	Iowa *G. macropus.* N. Y. ditto.	No *Roestelia.* ditto.	No *Roestelia.* ditto.	No *Roestelia.* ditto.
Red Astrachan,	Iowa *G. macropus.* N. Y. ditto.	Yellow spots on a few leaves. ditto	No further development. ditto.	No further development. ditto.
Ben Davis,	Iowa *G. macropus.* N. Y. ditto.	Not observed. ditto.	Yellow spots on a few leaves. ditto.	No further development. ditto.
Red Pippin,	Iowa *G. macropus.* N. Y. ditto.	No *Roestelia.* ditto.	No *Roestelia.* *Roestelia* appearing.	No *Roestelia.* Partially developed.
Maiden's Blush.	Iowa *G. macropus.*	*Roestelia* appearing.	Continuing to develop.	Aecidia well developed.
Wealthy,	Iowa *G. macropus.*	*Roestelia* appearing.	Continuing to develop.	Aecidia well developed.

*All inoculations with N. Y. *G. macropus* were made May 18.
All inoculations with Iowa *G. macropus* were made May 24.

The experiments at Ames, Iowa, were conducted at the Agricultural college. May 26, 1895, *G. macropus*, from New York, was inoculated on Yellow Transparent, Grimes' Golden, Duchess of Oldenburg, Whitney's No. 20 and *Pirus coronaria*. A large number of leaves on one tree of each were inoculated. In each case, some of the leaves were rubbed on both surfaces with the moistened cedar-apple horns, while others were inoculated by making punctures with a sterilized scalpel. On the same day, other trees of the same varieties were inoculated in the same manner with *G. macropus* collected in Iowa. All of the inoculations, except those on *Pirus coronaria*, failed. But the *Pirus coronaria* trees were so completely covered with *Roestelia* that scarcely a single perfect leaf could be found. What part of this was due to artificial inoculation and what part to natural inoculation it is impossible to say. It simply shows that the season was a favorable one for *Roestelia*.

Our experiments at Ames are entirely in accord with those made by Doctor Halsted and Professor Pammel. Taken in

connection with our experiments on Long Island, they show that some varieties (notably Yellow Transparent) are wholly exempt from *Roestelia pirata* and that there is good reason for believing that the absence of *Roestelia* from cultivated apples in Iowa is not due wholly to unfavorable climatic conditions, but chiefly to the fact that the varieties grown there are not susceptible to the disease. The severe climate of this section has obliged orchardists to abandon all except the most hardy varieties. These are mostly either Russian varieties or varieties which have originated in the northwest. However, the fact cannot be overlooked, that Wealthy, a variety shown by our own experiments to be very susceptible on Long Island, is frequently planted in Iowa, Wisconsin and Minnesota and is there exempt from *Roestelia*. We have by no means a complete solution of this problem.

In the Long Island experiments it is interesting to note that while some varieties showed themselves wholly exempt and others were very susceptible, there were also varieties which presented intermediate degrees of susceptibility. Yellow Transparent showed no signs of *Roestelia*; Maiden's Blush and Wealthy contracted the disease readily and matured æcidiospores; on Ben Davis and Red Astrachan the *Roestelia* started to grow but never reached maturity; on Red Pippin, only part of the æcidiospores matured.

There are few fungous diseases of cultivated plants which are equally distructive to all of the varieties of the species which they attack. Usually some varieties are much more severely attacked than are others. Some varieties may be but slightly affected, while others are ruined. Observant fruit growers know that Flemish Beauty "scabs" worse than most other varieties of pears, while the fungus which produces the leaf-blight and cracking of the pear, *Entomosporium maculatum*, Lev., has a preference for the variety White Doyenne. Wheat growers know that some varieties of wheat are more liable to rust than are others. These are but a few examples. Many more might be mentioned. In the case of *Roestelia pirata*, this preference for certain varieties is carried to the extremes. We know of no other fungus which attacks some varieties of a species so severely and yet cannot even be inoculated upon a large number of other varieties of the same species. Carnation rust, *Uromyces caryophyllinus* (Schrank) Schrœter, perhaps most nearly apprcaches it. This rust is exceedingly destructive

to some varieties of carnations, while several other varieties are nearly exempt from its attacks. One variety (Wm. Scott) is notably immune. We know of no well authenticated case in which the true rust *(Uromyces)* has been found upon this variety, although we have repeatedly observed it growing in greenhouses where other varieties were badly rusted.

In the present state of knowledge concerning the conditions of parasitism, it is impossible to completely explain the immunity of varieties. The structure and chemical composition of a variety are intimately associated with its susceptibility or non-susceptibility to the attacks of a particular fungus; but what is the relative importance of these, or what part is played by the mysterious factor called "inherent vigor" we do not know.

In conclusion we will record our observations on the effect of moisture on the prevalence of *Gymnosporangium* and Rœstelia. In the spring of 1894 *G. macropus* was fairly abundant at Ames, but the spring and summer were very dry, and, as a consequence of the drouth, *Roestelia pirata* on *Pirus coronaria* was rare. As previously stated, even attempts at *inoculation* of *P. coronaria* failed that season. In the spring of 1895 showers were frequent during the month of May. This season *Roestelia* was so abundant on *P. coronaria* that it was difficult to find leaves which were *not* affected. Everywhere the wild crab trees were conspicuous because of the *Roestelia* on their leaves.

On Long Island the summer of 1894 was very dry. The Red cedar grows spontaneously here and is very common. May 15, 1895, we searched very carefully through a large grove of Red cedars standing near an orchard and found only *three* cedar apples. At Westbury, N. Y., a Red cedar standing in the midst of a nursery bore only *two* cedar apples. At Queens, N. Y., three Red cedar trees grew on one side of a road, on the other side of which was an orchard; not a single cedar apple could be found on the cedars.

PRELIMINARY NOTES ON THE IOWA ENTOMOSTRACA.

BY L. S. ROSS.

The careful work done by a few investigators has shown the relation existing between our common fresh water fish and the minute crustacea of the streams and lakes. The results of these investigations prove the importance of the Entanostraca as a source of food supply for the young fry of many species, and even for the adults of some. The most extensive work upon this subject is that done by Dr. S. A. Forbes of the University of Illinois. An account of the methods pursued and of the results obtained is given in the bulletins of the Illinois State Laboratory of Natural history; Bulletins Nos. 2, 3 and 6, and articles VII and VIII, Vol. II.

Since the young fish depend for subsistence, to such an extent, upon the relative abundance or scarcity of the Entomostraca, it becomes a question not only of scientific interest, but of economic importance to learn concerning the distribution and abundance of the various species of this group of our fresh water fauna. The knowledge of the vertical distribution of different species in the lakes is of importance because some species of fish feed at one level and some at another. Some have their favorite haunts among the weeds of the shallows, others in the clearer, deeper waters.

Consideration of these facts induced me to begin work upon the occurrence and distribution of Entomostraca in the state of Iowa. The paper presented is a report of work begun, rather than work completed.

In order to combine pleasure with business, I decided to make a bicycle journey to the lake region of Iowa. In the first part of August of the past year, Mr. McCormack of Drake University, and myself started across country en route for Lake Okoboji. We carried vials of alcohol and a coarse and a fine net; the latter being of bolting cloth. The streams did not

offer good collecting ground at that season of the year, as they were nearly all dry. As we did not wish to overburden ourselves, we did not collect dried mud from the ponds and water courses.

Collections were made in a few places from the streams, but principally from West and East Okoboji and Spirit Lake, ranging from the surface to a depth of twenty feet. With the limited apparatus and short time at our disposal, not all the species of the lake were taken, very probably only a minority. To make a thorough investigation the apparatus should be such that hauls could be made among the weeds and along the bottom of the lake, as well as in the clear surface water. Not only should the nets be such as are needed to collect from places of all kinds, but such should be used as are necessary to determine the quantity of life in the water. For collecting in open water or where there is some rubbish, the ordinary fine-meshed net protected by two coarser nets, one outside and the other inside may be used. The inner coarse net should not be as deep as the fine one; it serves to catch and hold back the rubbish. The net or cone-dredge devised by Dr. E. A. Birge of Wisconsin, is the best for collecting among weeds. For quantitative work the plankton apparatus should be used. This is so arranged that the net can be drawn through the water at a definite rate of speed, the speed being regulated so there will be no overflow of water from the mouth of the net. The contents of the net are determined quantitatively as compared with the known amount of water that passed through.

As yet I have determined no species outside the order Cladocera. Of this order probably twenty-five species and varieties have been noted but no new ones have been described, nor have any new to America been found. Undoubtedly, with better apparatus and with more literature upon the subject, many more species may be collected and determined.

The following families are represented in the collections:

Sididae.—By the genera, *Sida* and *Daphnella.*

Daphniidae.—By the genera, *Simocephalus*, *Ceriodaphnia*, *Scapholeberis* and *Daphnia.*

Macrothricidae.—By the genera, *Macrothrix* and *Iliocryptus.*

Lynceidae.—By the genera, *Eurycercus*, *Alona*, *Dunhevedia*, *Pleuroxus*, *Chydorus*, *Camptocercus* and *Leydigia.*

Leptodoridae.—By the genus *Leptodora*

The species found are as follows:

Family *Sididae*	*Sida crystallina* O. F. M. *Daphnella brachyura* Liev.
Family *Daphniidae*	*Simocephalus vetulus* O. F. M. *Simocephalus serrulatus* Koch. *Ceriodaphnia reticulata* Jur. *Ceriodaphnia consors* Birge. *Ceriodaphnia lacustris* Birge. *Scapholeberis mucronata* O. F. M. *Scapholeberis obtusa* Schdl. *Daphnia hyalina* Leydig. *Daphnia kalbergensis* Schoedler. *Daphnia kal.* var., *retrocurva* Forbes *Daphnia sp?*
Family *Macrothricidae*	*Macrothrix laticornis* Jur. *Iliocryptus sordidus* Lieven.
Family *Lynceidae*	*Eurycercus lamellatus* O. F. M. *Alona sp?* *Dunhevedia setiger* Birge. *Pleuroxus denticulatus* Birge. *Pleuroxus procurvatus* Birge. *Chydorus sphaericus* O. F. M. *Chydorus globosus* Baird. *Leydigia quadrangularis* Leyd. *Camptocercus rectirostris* Schdl.
Family *Leptodoridae*	*Leptodora hyalina* Lillj.

The distribution of the species is given in the table:

West Okoboji, open lake, from six to eight feet below surface	*Daphnella brachyura.* *Daphnia kalbergensis.* *Daphnia kal.*, variety *retrocurva.* *Daphnia hyalina.* *Ceriodaphnia lacustris.* *Chydorus sphaericus.* *Chydorus globosus.* *Leptodora hyalina.*
West Okoboji, among weeds near shore	*Sida crystallina.* *Ceriodaphnia consors.* *Simocephalus serrulatus.* *Chydorus sp?* *Pleuroxus denticulatus.* *Pleuroxus procurvatus.*
Streams near Newell, Iowa	*Ceriodaphnia reticulata.* *Simocephalus serrulatus.* *Simocephalus vetulus.* *Scapholeberis mucronata.* *Pleuroxus denticulatus.* *Chydorus sphaericus.*

West Okoboji, fifteen to twenty feet below surface	*Daphnella brachyura.* *Daphnia kal.*, variety *retrocurva.* *Simocephalus serrulatus.* *Ceriodaphnia consors.* *Eurycercus lamellatus.* *Dunhevedia setiger.* *Chydorus sphaericus.* *Chydorus globosus.* *Camptocercus rectirostris.*
East Okoboji, surface	*Sida crystallina.* *Ceriodaphnia reticulata.* *Ceriodaphnia consors.* *Daphnia kal.*, variety *retrocurva.* *Daphnia hyalina* *Macrothrix laticornis.* *Eurycercus lamellatus.* *Chydorus sphaericus.* *Leydigia quadrangularis.*
Spirit Lake, ten to fifteen feet below surface	*Daphnella brachyura.* *Daphnia kal.*, variety *retrocurva.* *Chydorus sphaericus.*
Raccoon River, Adel, Iowa	*Ceriodaphnia reticulata.* *Scapholeberis mucronata.* *Iliocryptus sordidus.* *Pleuroxus denticulata.*
Raccoon River at Sac City	*Scapholeberis mucronata.* *Simocephalus serrulatus.* *Chydorus sphaericus.* *Pleuroxus denticulatus.* *Alona sp?*

THE ANATOMY OF SPHÆRIUM SULCATUM LAM.

BY GILMAN A DREW.

For a number of years the embryology of the Cyrenidæ has been attracting considerable attention, but little has been added to our knowledge of the general anatomy since Dr. Franz Leydig's publication in 1855 (No. 5), who recorded such anatomy as could be made out from young and rather trans parent specimens.*

It is my present intention to continue the work here begun on Sphærium to a comparative anatomy of the Cyrenidæ, but in

*I find a reference to a paper by Temple Prime, entitled: Notes on the Anatomy of the Corbiculidæ and Translation from the Danish of an article on the Anatomy of Cyclas by Jacobson. Bul. Museum Comp. Zool., Cambridge, Vol. V. This volume unfortunately is not to be found in the reference libraries of Baltimore.

the meantime it seems to me that the anatomy of a single genus and a single species of that genus may not be wholly without interest, especially to those who are working in the interior, where the Unionidæ and Cyrenidæ are the only available Lamellibranchs.

Regarding the systematic position of Sphærium, suffice it to say that the old genus Cyclas includes the present genera Sphærium and Pisidium, and that these, with four or more other generally accepted genera, go to form the family which has been variously known as Cycladæ, Corbiculidæ and Cyrenidæ.

SHELL.

(Fig. 2.) The shell of this species is comparatively thick, of a dark horn color, frequently lighter near the margins of the valves, and is composed of a rather thick bluish-white nacre, covered exteriorly by epidermis. The lines of growth are well marked. The teeth are thin lamellæ, 2–2 on the right valve and 1–1 on the left valve. The adductor scars, *a s* and *p s*, are quite distinct and are joined dorsally by the retractor pedis scars. The pallial line is rather obscure. A large specimen measures 15x12x9 mm.

MANTLE.

The mantle consists of two thin lobes of connective tissue covered by epithelium, free at their anterior and ventral margins, united to form the siphons posteriorly, and continuous over the back. The lobes lie closely applied to the shell nacre, which is secreted by them, and are attached to the nacre at the pallial line by the pallial muscles, and to the epidermis through the epidermal gland, which lies in a groove in the mantle margin. A ridge, Fig. 3, *r*, extending from the ventral end of the anterior adductor muscle to the branchial siphon, runs along the inside of each mantle lobe near its ventral margin and serves, by meeting its fellow on the opposite lobe, or sides of the foot in case that organ is protruded, to close the open side of the branchial chamber and force currents of water to enter through the branchial siphon, which is protruded above the mud or sand in which the animal lives. The siphons, Figs. 1 and 3, *b s* and *c s*, are quite muscular and are capable of considerable protrusion. Neither one is fringed with tentacles.

MUSCULAR SYSTEM.

The muscular system may for convenience be classed as adductors, retractors, foot muscles and mantle muscles, including those of the siphons.

The adductors, Figs. 1 and 3, are two in number, anterior, *aa*, and posterior, *pa*. They differ slightly in size and shape, and have for their only function the closing of the shell.

There are two pairs of retractors, anterior and posterior retractor pedis muscles, Figs. 1 and 3, *a r p* and *p r p*. They serve to withdraw, or retract, the foot from an extended position.

The foot is largely made up of crossing muscle fibers, extending more or less in all directions, but capable of being classed as longitudinal, vertical and horizontal. They aid in protrusion, by forcing the blood where most efficient, in retraction and in special movements of the protruded foot.

The pallial muscles, Figs. 4 and 5, are distributed to the inner end of the epidermal gland in the edge of the mantle and to the ridge already described. They serve to withdraw the edge of the mantle from between the edges of the valves when the valves are tightly closed.

BYSSAL GLAND.

A rudiment of the byssal gland, Fig. 1, *b*, persists in the adult animal as a single closed sack, often showing a slight sagittal constriction. It is supplied with a small nerve on each side, which spring from trunks that have their origin in the pedal ganglia. Most of the specimens which I have examined have the rudiment of the byssal gland nearer the pedal ganglia than is shown in Fig. 1.

GILLS.

The gills, four in number, consist of a pair, an outer and an inner gill, on each side of the body. The outer, Fig. 3, *o g*, is much smaller than the inner, *i g*, and falls short anteriorly by about a fourth of its length. Each gill is composed of two lamellæ. The outer lamella of the inner gill is attached to the inner lamella of the outer gill on the same side, the outer lamellæ of the outer gills are attached to the mantle lobes on their respective sides, and the inner lamellæ of the inner gills are attached anteriorly to the body wall and posteriorly to each other, Fig. 5. The gills function as respiratory organs, procurers of food and brood pouches. The latter function is monopolized by the inner gills, which carry the embryos until they are ready to function as adults.

Fig. 6, which represents a piece of gill cut squarely across the lamellæ and seen obliquely from the cut surface so that the

side of a lamella may be seen, may aid in understanding the structure of a gill. The descending and ascending portions of each filament, *f i l*, are fused throughout their length, thus uniting the lamellæ at very short intervals and restricting individual water-tubes, *w t*, between adjacent filaments.

The filaments are strengthened by chitinous rods, *c r*, and attached to one another laterally by inter-filamenter junctions, *i f j*, which are places where, during development, adjacent filaments have fused together. There are thus left openings, *i o*, known as inhalent ostea, which lead into the water-tubes. Beneath the epithelial covering of the filaments is a loose connective tissue, through which more or less definite blood spaces, *b l s*, may be traced. The outer surfaces of the filaments are covered with rather short cilia, besides which there is a row of longer cilia on each side of each filament near the outer surfaces, and another row of long cilia placed far in on the sides of the filaments, nearly opposite the chitinous rods. It seems that the inner rows of cilia serve largely to drive the water through the inhalent ostea and water-tubes and thus keep up a continuous supply of fresh water, while the other cilia are engaged in forming surface currents and in separating and transporting food particles.

LABIAL PALPI.

The labial palpi, Fig. 3, *l p*, are very long and slightly curved. There is a pair, consisting of an outer and an inner palp, on each side of the body. The anterior edges of the outer palps are connected in front of the mouth by a slight ridge, as are likewise the anterior edges of the inner palps behind the mouth. The adjacent sides of each pair are grooved and densely ciliated. Particles of food passed between them from the gills are transported to the mouth.

ALIMENTARY CANAL.

The mouth, situated behind the anterior adductor muscle leads into a rather long and slender œsophagus, Fig. 1, *o e*, which communicates with a somewhat spacious horn-shaped stomach, sacculated at its upper end, which curves downward and forward and gradually tapers into the intestine which at this point forms a coil. The relative positions of the loops of this coil to one another, may be made out by comparing Fig. 1, with Fig. 4, which latter represents an obliquely transverse section through the coil. The stomach 1, situated on the left

side of the body, communicates anteriorly with 2, which, near the plane of the section turns to form 3, and so on. It is of interest to note that in the young animals no such coil exists. As the alimentary canal lengthens the loops are formed and gradually lengthen. Fig. 1 is reconstructed from a smaller and apparently younger individual than the one represented in section by Fig. 4, and it will be observed that the loop *4 5*, Fig. 4, must be longer than the corresponding loop of Fig. 1, else the arms could not be separate at a point where the loop *2 3*, is turning. From the point *6*, the intestine follows back along the convex border of the stomach, then rather abruptly turns nearly at right angles to its former course, passes through the ventricle of the heart, then passes over the posterior adductor muscle dorsally and posteriorly to open in the cloacal chamber. The typhlosole is not strongly developed but is present as a small ridge as shown in Fig. 5.

The alimentary canal throughout its length is lined by elongated ciliated epithelial cells. Fig. 9 represents these cells as they appear in a section through the lower end of the stomach.

LIVER.

The liver, Fig. 1, *l*, is a paired organ, consisting of two large racemose glands, one on each side of the body. Each gland communicates with the stomach through anterior lateral pouches. The liver cells are often densely crowded with granules that stain deeply, but not infrequently part of the cells of some follicles will be full while adjacent cells will be empty. This condition is indicated by Fig. 10.

It is not unlikely that, as the animal probably feeds most of the time, digestion is a continuous process and that the liver cells are continually filling up and discharging.

NERVOUS SYSTEM.

The regular three pairs of Lamellibranch ganglia are present. The cerebral ganglia, Fig. 1, *c. g.* lie on opposite sides of the œsophagus, on a level with the dorsal end of the anterior adductor muscle. They are somewhat oblong in shape and are connected with each other by an œsophageal commissure which runs between the œsophagus and the anterior adductor muscle. The parieto-splanchnic ganglia Fig. 1, *p s g*, also oblong in shape, lie anterior to the ventral portion of the posterior adductor muscle and are fused together by their adjacent sides. The pedal ganglia, Fig. 1, *p g*, are more nearly circular than

either of the other ganglia, when viewed from the side. They lie beneath and a little posterior to the intestinal coil at the line where the muscles of the foot come in contact with the connective tissues of the body proper, Fig. 4. The pedal ganglia are likewise fused together by their adjacent sides.

The cerebral ganglia are connected, Fig. 1, with the parieto-splanchnic ganglia by the cerebro-visceral commissures and with the pedal ganglia by the cerebro-pedal commissures. Beside these commissural connections each cerebral ganglion gives rise to a small nerve which supplies the anterior adductor muscle and a larger nerve which passes down behind the anterior adductor muscle into the mantle and supplies the pallial muscles of its anterior portion.

Each parieto-splanchnic ganglion besides its commissural connection, gives rise to a small nerve which supplies the posterior adductor muscle, a larger branchial nerve which runs forward a short distance, passes over into the junction of the outer lamella of the inner gill with the inner lamella of the outer gill, where it turns abruptly backward and apparently ends at the posterior ends of the gills not greatly reduced in size, and a large nerve that runs around the ventral surface of the posterior adductor muscle and branches. The smaller branch is probably distributed to the muscles of the siphons, but I have been unable to follow it far. The larger branch runs along the mantle near the inner ends of the pallial muscles, giving off a branch near the upper border of the branchial siphon and numerous small branches to the pallial muscles.

Each pedal ganglion, besides its commissural connection, gives rise to at least five more or less distinct nerves which branch among the muscles of the foot.

OTOCYSTS.

A pair of otocysts, Fig. 1, *o t*, lie directly in front of the pedal ganglia, almost, if not quite in contact with the cerebro-pedal commissures. They are nearly spherical in shape, and consist of a wall of cells with a nearly spherical otolith inside (Nos. 4 and 5). Thus far I have been unable to find cilia in the otocysts, but this may be the fault of preservation. The otocysts of most Lamellibranches are described as being enervated by fibres from the cerebro-pedal commissures. With Sphærium a small branch is given off from the nerve which passes immediately below each otocyst that passes up, and may

often be traced into contact with the otocyst, but I have been unable to demonstrate actual connection with this or with fibres from the cerebro-pedal commissure. Regarding the function of otocysts see Dr. Brooks' article (No. 1).

CIRCULATORY SYSTEM.

The heart, Figs. 1 and 5, consisting of a single median ventricle, *v t*, and a pair of lateral auricles, *a u*, lies in the pericardial cavity, near the dorsal surface of the animal, and somewhat in front of the posterior adductor muscle. All the blood channels issuing from the ventricle are without very definite walls or calibre. Immediately in front of the pericardium the blood channel, Fig. 1, which leaves the heart in this direction, divides. The larger branch is continued forward along the dorsal line of the body, turns to the left and passes beneath the œsophagus, which it follows to the mouth. When opposite the dorsal end of the anterior adductor muscle, a branch is given off which passes in front of the adductor and, dividing, sends a branch to each mantle lobe. The main channel is continued down in front the cerebro-pedal commissures into the foot, where it divides into a number of small branches that apparently ultimately end in the connective tissue spaces with which the whole body is permeated. The smaller branch, which arises immediately in front of the pericardial cavity, passes downward, sends a branch to either side of the stomach, supplying that organ throughout its length with small branches, and finally ends among the loops of the intestinal coil.

Posteriorly the ventricle gives rise to a channel of considerable dimensions which surrounds the intestine, but is more spacious beneath than above it. The intestine seems to be held in the dorsal part of this channel by strands of connective tissue. Behind the posterior adductor muscle this channel widens on opposite sides of the intestine and is continued into the mantle lobes. It is not improbable that other important channels exist. Fig. 5 is a section across the body in the region of the heart showing the connection that exists between the auricles and the blood spaces of the gills.

ORGANS OF BOJANUS.

The organs of Bojanus consist of a pair of coiled and sacculated tubes, one on each side of the body, lying between the pericardium and the posterior adductor muscle. At one end

each organ opens into the pericardial cavity, and at the other end into the cloacal chamber. Fig. 1, *o B*, shows the right organ as seen from the left or inner side, and Fig. 7 is a diagram of the left organ as seen from the left or outer side. By comparing the two figures the relations of the loops will be seen. The cells lining the organ are apparently not glandular in the immediate vicinity of the pericardial opening, and are rather small near the cloacal opening, but throughout the rest of the tube the cells are large and vacuolated, as shown by Fig. 11, which represents specially large cells from the dorsal part of the organ. I have been unable to find cilia on any of the cells.

REPRODUCTIVE ORGANS.

The animal is hermaphroditic. The reproductive organs, which are paired, each consist of a racemose gland, Fig. 1, *r o*, situated beneath the pericardium and behind the stomach, varying in extent according to the age of the individual, and opening into the cloacal chamber close to the cloacal opening of the organ of Bojanus. Part of the follicles bear ova, others sperm. The ova-bearing follicles are generally among those most posterior. They are fewer in number than the sperm follicles, and, in this species, bear comparatively few ova. Fig. 8 represents a section of an ova-bearing follicle, in which are a number of nearly or quite mature and several very young ova. The sperm-bearing follicles are generally full of sperm, which lie free in their cavities. Reproduction, apparently, goes on during the greater part of the year.

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My thanks are due to Mr. C. P. Sigerfoos for the loan of series of sections of two undetermined species of Sphærium, with which some comparisons were made.

EXPLANATION OF PLATES.

a a. Anterior adductor muscle.
a o. Anterior aorta.
a r p. Anterior retractor pedis muscle.
a s Anterior adductor muscle scar.
a u. Auricle.
b. Byssal gland rudiment.
b l s. Blood space.
b s. Branchial siphon.
c. Cloacal chamber.
c g. Cerebral ganglion.
c r. Chitinous rods.
c s. Cloacal siphon.
f. Foot.
f i l. Gill filament.
i f j. Inter-filamentar junctions.
i g. Inner gill.
i o. Inhalent ostea.
l. Liver.
l p. Labial palpus.
m. Mantle.
o B. Organ of Bojanus.
œ. Œsophagus.
o g. Outer gill.
o t. Otocyst.
o v. Ovarian follicle.
p. Pericardial cavity.
p a. Posterior adductor muscle.
p g. Pedal ganglion.
p r p. Posterior retractor pedis muscle.
p s. Posterior adductor muscle scar.
p s g. Parieto-splanchnic ganglion.
r. Mantle ridge.
r o. Reproductive organs.
t. Male follicle.
v t. Ventricle.
w t. Water-tube.

PLATE I.

Fig. 1. A reconstruction of an adult specimen from serial sections, seen from the left side. Median, and the paired organs of one side shown. The liver and reproductive organs of older specimens are more extensive.

PLATE II.

Fig. 2. Enlarged view of the outside of the right valve and the inside of the left valve of a shell.
Fig. 3. View of the animal with the right valve of the shell removed, and most of the right mantle lobe cut away.
Fig. 4. Oblique cross-section of an animal through the intestinal coil and the pedal ganglia. Seen from behind.
Fig. 5. Section through the heart in the same series as preceding.

PLATE III.

Fig. 6. Cross-section of a piece of gill seen obliquely from the side so as to show both the section and the outer surface of a lamella.
Fig. 7. Diagram of the outer, left, side of the left organ of Bojanus.
Fig. 8. Section across an ovarian follicle.
Fig. 9. Epithelial lining of the distal portion of the stomach.
Fig. 10. Liver follicle showing charged and discharged cells.
Fig. 11. Epithelial cells of the organ of Bojanus.

A STUDY OF THE GENUS CLASTOPTERA.

ELMER D. BALL.

In the development of the hind tibiae and the structure and venation of the wings, the insects under consideration represent the highest and most specialized forms of the Cercopidæ if not of the Homoptera; marking, as Uhler suggests, an important advance toward the Heteroptera in the increased freedom of the anterior coxae and the possession of a terminal membrane to the corium.

In order to correctly establish generic characters it will be necessary, first, to separate off those of family value.

FAMILY CERCOPIDÆ.

The representatives of the family in this country, at least, agree in possessing the following characters:

Front inflated, convex or compresso produced; antennae inserted in front of and between the eyes; ocelli, two, situated on the disc of the vertex; thorax large, sexangular or trapezoidal; hemelytra coriaceous; posterior coxæ and femurs short, tibiæ spatulate, armed with two spurs, the first once, the second twice as long as tibiæ are wide; tibiæ and two first joints of tarsi terminated with crescent-shaped rows of spines, third joint with a bifid claw.

The following genera are represented in the United States: *Monecphora*, *Lepyronia*, *Aphrophora*, *Philaenus* and *Clastoptera*. These may be easily separated by the character of the venation of either pair of wings by reference to plate XII.

The *Clastoptera* may be separated from the others, directly, by the rounded apex of the clavus and the terminal membrane of the corium.

CLASTOPTERA.

Germar's original description published in his "Zeitschrift fur Entomologie," Vol. I, p. 157, is as follows:

Kopf gross, stumpf dreieckig, so breit wie der Vorderrucken, Stirn gewolbt, queerstreifig, Scheitel breit viereckig, vorn und hinten scharf gerandet, die Nebenaugen auf der mitte des Scheitels genahert. Schnabel bis an die Hinterbrust reichend. Fuhler in einer Grube an der Wurzel der Wangen, sehr kurz, mit langer feiner Endborste. Vorderrucken breit am Scheitel vorgezogen und gerundet, bei den Augen gebuchtet, von den Schultern nach hinten in einer Rundung verschmalert, an der spitze schmal aber tief ausgerandet. Schildchen ein langgezogenes spitzwinkeliges dreick bildend. Deckschilde lederartig, an der Spitze gewolbt, uber einander klapfend, die hintere Randader weit von dem Hinterrande entfernt. Flugel hautig, unter den Deckschilden vorborgen. Beine maszig lang, unbewehrt um die hintersten verlangert, mit zwei stacheln am Rucken die Schienen und einem Dornenkranze an der Spitze der Schienen, und ersten beiden Tarsengliedern.

A careful study of all the American forms leads to the following summary of characters:

Broad, oval forms; very variable in size and color markings; front inflated, circular, not longitudinally carinated; antennæ arising from a deep cavity between the eyes, basal enlargement not extending outside of cavity; vertex narrow, transversely depressed, outline regular, not inclosing front; eyes broad, a row of curved hairs on the outer and posterior margin; pronotum convex, trapezoidal, transversely wrinkled, deeply emarginated behind; scutellum narrow, triangular, longer than pronotum; hemelytra convex, deflected posteriorly, overlapping behind in a perpendicular plane; corium with three apical cells and two widely separated discoid cells, a broad membrane beyond; membrane and apical cellules hyaline; clavus with apex broadly rounded; an oval, convex, callous dot near apex of hemelytra; under wing with a single discoid cell, terminal apical cell open; posterior tibia with a single terminal row of spines: ovipositor carried perpendicular to the plane of the body: males usually smaller and slightly darker than females; smallest varieties nearly black.

Specific characters are based upon the size and shape of front, the facial angle, sculpturing of vertex and pronotum, size and shape of discoid and apical cells, pubescence of pronotum and hemelytra, and the color markings of the face and legs.

Sub-species are based upon size, food habits and associated groups of constant color markings; varieties, on locality, size and color markings of vertex, pronotum and clavus.

SYNOPSIS OF SPECIES.

A. Front strongly inflated, rising abruptly from face at sides, meeting vertex in same plane: pronotum with broad wrinkles; first discoid cell equal to second.

B. Front, outline a regular curve, entirely black, or yellow with transverse interrupted brown bands above, light below; pronotum scabrous, with about eight distinct wrinkles; veins on clavus prominent ..... *delicata*, Uhl.

BB. Front, outline an irregular curve, upper half black with a narrow yellow margin next to vertex, lower half yellow, loræ and clypeus yellow; pronotum, bare, with about twelve indistinct broad wrinkles ..... *proteus*, Fitch.

AA. Front, less inflated, rising gradually from face at sides, meeting vertex at an obtuse angle above; pronotum finely, sharply wrinkled, about twenty on the median line; first discoid cell smaller than second.

B. Hemelytra strongly impunctured, sparsely pubescent; second apical cell short and broad; insects small, of a uniform color above ..... *xanthocephala*, Germ.

BB. Hemelytra minutely impunctured, thickly finely pubescent, second apical cell long and narrow; insects large, usually banded above ..... *obtusa*, Say.

ARTIFICIAL KEY TO SPECIES.

A. Face entirely black ..... *delicata-lineata*, var. *b.* or *binotata*.

AA. Face not entirely black.

B. Upper half of front black; loræ, clypeus and lower half of front yellow ..... *proteus*.

BB. Upper half of front light with transverse, interrupted, brown bands

C. Pronotum with five transverse straight black bands, not parallel with anterior margin ..... *delicata-lineata*, var. *a*.

CC. Bands on pronotum parallel to anterior margin or wanting.

D. Hemelytra strongly impunctured, sparsely pubescent; pronotum without bands; lower half of face with a light band; insects small ..... *xanthocephala*.

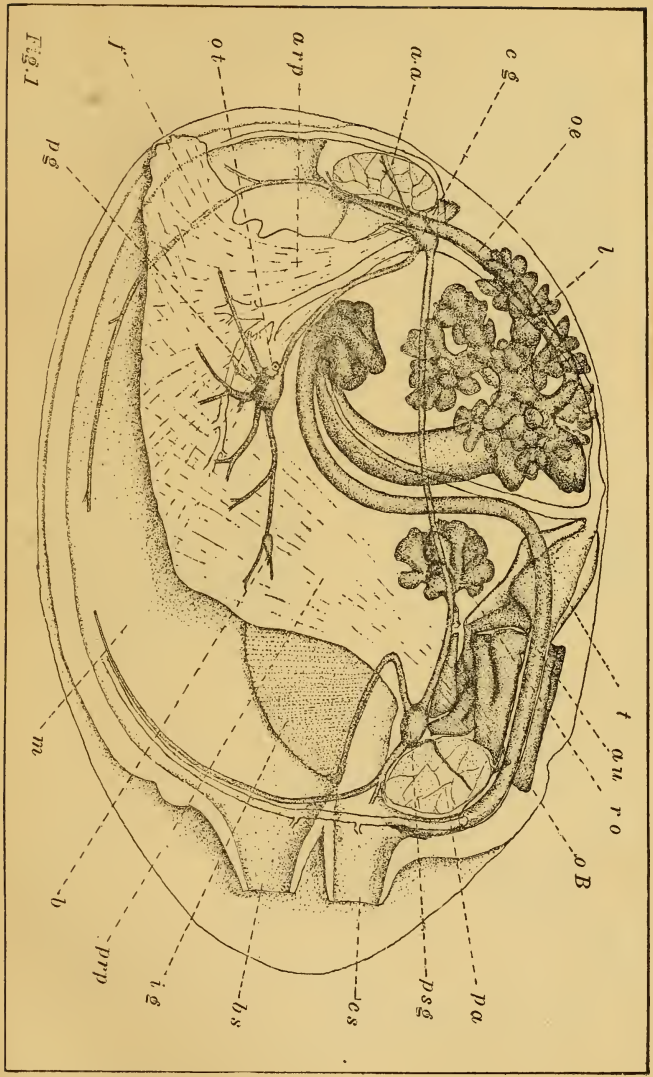
DD. Hemelytra minutely impunctured thickly, finely pubescent; pronotum generally banded or colored where not, face all light; insects large ..... *obtusa*.

C. DELICATA UHL.

C. binotata Uhl. ms.

Uhler's original description found in his list of Hemiptera west of the Mississippi river is as follows:

Form of *C. proteus*, Fitch, but with a more prominent front. Pale greenish-yellow. Head broad, apparently impunctate: cranium short, transversely depressed, as is also the tylus: anterior edge of the vertex carinately elevated, bordered from eye to eye with a black line; eye margined behind with black; front smooth, polished, bright yellow, rounded, the transverse rugæ substituted by slender black bands; lower down grooved, and with a broad black spot, adjoining which each side on the cheeks is a smaller spot;



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under side bright yellow; rostrum black, reaching almost to the posterior coxæ; antennæ black at base. Pronotum banded on the anterior margin by a slender black line, and with five straighter and more slender lines which stop just short of the lateral margins, these lines feebly impressed and obsoletely, minutely scabrous, surface not wrinkled, almost smooth, moderately convex, deeply emarginated behind, the lateral margin narrowly produced as far as the outer line of the eyes; the humeral margin recurved, and with a small black dot before it. Scutellum pubescent, yellow, transversely wrinkled, with a slender black line at base, and an interrupted one behind the middle. Hemelytra with short, remote, golden pubescence, coarsely punctate at base, more obsoletely so posteriorly; the inner and posterior margins, the suture between the corium and clavus, an oblique short streak on the disc, and a spot on the middle of the costa fuscous: posterior margin of the corium with a sinuous brown band, the membrane and posterior one-third of the corium, and spot at base of costa pale brown; the bulla very prominent, black; under side yellow; the mesosternum, discs of the plural pieces, and middle line of genital segment pitch black Legs, yellow, the tibiæ having a band below the knee, another on the middle, and a third at tip, and the spines of tibiæ and tarsi, including the nails, dark piceous.

Length to the tip of hemelytra, four and one-half mm., width of pronotum, two mm.

After a careful study of representatives from every state from which it has been reported so far, the following description, embracing only characters of specific value was prepared.

Size variable; color from yellow to black; front much inflated; two circular yellow depressions on vertex near eyes; pronotum strongly, broadly wrinkled.

Front rising abruptly from face at sides, meeting vertex in same plane above, outline a regular curve. Vertex very slightly transversely depressed; a distinct, circular, yellow depression midway between eye and ocellus on either side. Pronotum coarsely pubescent, strongly, transversely, wrinkled, about eight on the median line. Hemelytra coarsely pubescent; veins on clavus strongly raised; apical cells transversely compressed, third cell triangular, not reaching beyond angle of posterior marginal vein. Legs stout; spurs and spines strong; femur and tibia with dark lateral lines coalescing with two dark spots on outside of tibia.

Sub. sp. I. *lineata*. Pronotum yellow, with five black bands.

Var. *a*. Clavus with veins and margin yellow inclosing dark areas.

b. Clavus entirely fuscous.

Sub. sp. II. *binotata*. Pronotum entirely black.

Habitat: Utah (Uhl), Cal. Col. and Ariz.

This species is so widely variable that with only the extreme forms there would be no hesitancy in pronouncing them separate species, but with a large amount of material a series can be found which clearly establishes their relationship. Uhler's description is an absolutely perfect one for Sub. sp. *lineata* var.

a, but would apply only slightly to var. *b*, and would absolutely exclude Sub. sp. *binotata*.

C. binotata was a ms. name given to that var. by Uhler, I believe, and under which name specimens have been distributed in collections.

C. PROTEUS, FITCH.

C. saint cyri. Prov.

The original description was published in the fourth annual report of the New York State Museum (1851). Republished in the ninth report of the State Entomologist of New York, page 394, from which the following description and sub-divisions are copied:

Head bright yellow, a black band on anterior margin of vertex and a broader one on the front; front polished, without transverse striæ; a callous black dot near the apex of the elytra; legs yellowish-white, tarsi black. Length, 0.16; males slightly smaller.

Closely allied to the *C. atra* of Germ , but on examining a host of specimens not one occurs in which the legs are annulated with black or fuscous.

He then divides the species up into sub-species and varieties as follows:

Sub. sp. I. *flavicollis.* Thorax entirely yellow.
- Var. *a.* Elytra yellow.
- *b.* Elytra with an oblique blackish vitta.

Sub. sp. II. *cincticollis.* Thorax with a black band.
- Var. *a.* An interrupted black band on the anterior margin of the thorax.
- *b* An entire black band on anterior margin of the thorax.
- *c.* Thoracic band crossing the disk instead of the anterior margin.
- *d.* Band on the disk of the thorax, and scutel black.

Sub. sp. III. *maculicollis.* Thorax with one or two discoidal spots.
- Var. *a.* A black spot on disk and an interrupted band anteriorly.
- *b.* A black spot on the disk and anterior band entire.
- *c* Two black spots on the disk of the thorax.

Sub. sp. IV. *nigricollis.* Thorax black, with a yellow band forward of the disk.
- Var. *a.* The black band on the anterior margin of the thorax interrupted.
- *b.* The band continuous.
- *c.* Scutel black, with a yellow dot at its base.
- *d.* Scutel entirely black.

Fitch's "host" of specimens were probably all from one locality and may all have belonged to one sub. sp , according to my classification below. At any rate I have at hand four specimens, that are all clearly and unquestionably varieties of

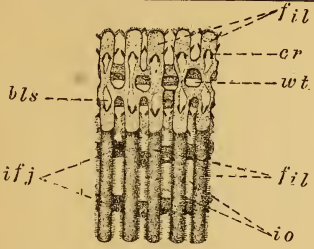

Fig.6

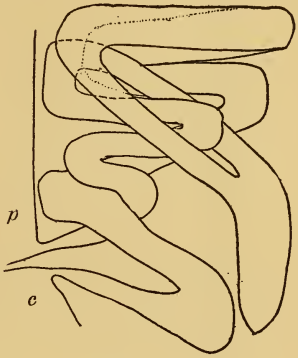

Fig.7

Fig. 11

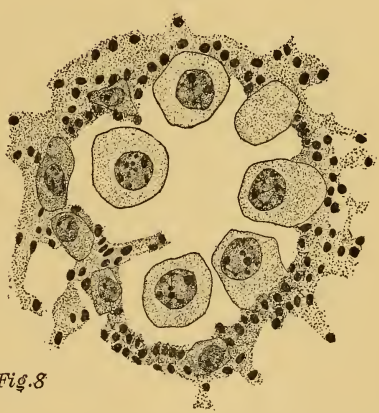

Fig.8

Fig.10

Fig.9

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my sub. sp. *vittata*, each one of which answers the requirements of a different sub. sp. of Fitch; on the other hand I have specimens which are unquestionably of different sub. sp., and occurring in widely separated localities which would be placed in the same sub. sp., and the same variety by Fitch's classification, clearly showing that the color of the pronotum is not of sufficient value on which to base sub-species. He made no provision for the black varieties and from his remark about the relationship of *C atra*, Germ., it is highly probable that he had none.

A careful study of about seventy-five specimens, embracing representatives from widely separated areas resulted in the adoption of the color marking of the clavus as a character constant for a given sub-species, and in the determination of specific characters as follows:

Size, medium; front strongly inflated, upper half black, lower half yellow; legs bright yellow, with lateral black lines.

Front rising abruptly from face at sides continuing in same plane as vertex above; upper half black; lower half, loræ and clypeus yellow, a black dot on center of clypeus. Vertex slightly, transversely depressed, anterior margin not distinctly carinated; suture between front and vertex indistinct. Pronotum bare, broadly, indistinctly, transversely wrinkled, wrinkles minutely striated, about twelve on the median line. Hemelytra with a fine short pubescence; first discoid cell wider than second second apical cell broad, nearly equal to third. Abdomen black or fuscous; legs bright yellow; a lateral line on front of femur, one on each side of tibia; all three joints of tarsi, and last segment of rostrum black. Length, four mm , width of pronotum about one and one-half mm.

Habitat: Iowa, Illinois (Forbes), Quebec, Canada, Ontario, Canada, New Hampshire, Massachusetts, Pennsylvania, New York, District of Columbia, New Jersey (Smith), West Virginia.

Sub. sp. I. *flava*. Anterior two-thirds of clavus yellow.
Var. *a*. Scutellum with a yellow spot
b. Scutellum black.
Sub. sp. II. *vittata* Clavus yellow with an oblique black vitta through the middle.
Var. *a*. Pronotum with one yellow band anteriorly.
b. Pronotum with two yellow bands.
c. Pronotum entirely yellow.

Habitat: New York, Pennsylvania, Massachusetts, Connecticut, District of Columbia.

Sub. sp. III. *nigra*. Clavus entirely black.
Var. *a*. A yellow band on vertex, and one on face next to vertex.
b. Yellow bands wanting; entirely black above; legs darker.

Habitat: West Virginia, Pennsylvania, District of Columbia, Massachusetts, New York.

Specimens of *C. saint cyri* Prov., that I have from Quebec, Canada, belong to sub. sp. *I. flava.*

C. XANTHOCEPHALA GERM.

Germar's original description (Germ. Zeit. fur die Ento., 1–189) is as follows:

Nigra, capite flavescente, frontis, fascia nigra, elytris maculis marginatibus hyalinis, puncta colloso ante apicum nigro, pedibus pallido-fuscaque annulatis.

Habitat in Pennsylvania, Carolina, Zimmermann. One and one-half lin lang. Kopf gelb, um der scheitel dunkel, eine queerbinde auf der unterseite schwarz. Deckschilde schwarz, ein Fleck am vorderrande vor der Spitze, ein anderer, der den ganzen Hinterrand einnimmt, glashell, latzterer mit einem schwarzen schwieligen Punkte vor der Vorderecke. Beine gelblich, braun geringelt.

This species is the most constant in size and coloration of any in the genus. From a study of over one hundred specimens representing every locality mentioned below, I have prepared the following description:

Small, brown or black without markings of any kind above; face with brown bands above, dark below with a distinct light band crossing the center; hemelytra very sparsely pubescent.

Front moderately inflated, light above with about nine transverse interrupted brown bands, band below these, and clypeus black, lorae, included portions of front, and margin of anterior coxal fossæ yellow. Vertex not strongly depressed; suture between vertex and front distinct. Pronotum with about nineteen fine indistinct wrinkles. Hemelytra strongly impunctured, very sparsely pubescent; second apical cell broad, irregularly wedge-shaped. Under side black; legs brown, spurs and spines tipped with black. Length, three and one-half mm., width of pronotum, one and four-tenths mm.

Var. *a.* Black above; a small white spot on center of costa.
b. Glaucus above.

Habitat: Mississippi, Arkansas, Texas, Louisana, Maryland, District of Columbia, Virginia, Florida, Iowa, Pennsylvania, Carolina (Walker) and New Jersey (Smith).

C. OBTUSA, SAY.

Cercopis obtusa Say. Jour. Acad. Nat. Sci., Phila., IV, 339. (1825.)
Clastoptera achatina Germ. Zeit fur die Ent., 1, 189. (1839.)
C. testacea Fitch. Fourth An. Rep. N. Y. State Mus. (1851.)
C. pini Fitch. Fourth An. Rep. N. Y. State Mus. (1851.)
C. lineatocollis Stal. Eng. Resa Omk. jord., IV, 236.
C. osborni Gillette. Hemip. Col., 71. (1895.)
C. stolida Uhl. ?
C. undulata Uhl. ?

Say's original description (Coll. Writings, Vol. II, page 256) is as follows:

♢ Head and anterior part of thorax pale, with three transverse lines; wings varied with brown and pale; body short, oval; head pale yellowish, an elevated, reddish-brown, transverse line between the eyes and before the stemmata; front with about nine parallel, equidistant, reddish-brown lines, which are interrupted in the middle and abbreviated in the cavity of the antennæ; antennæ placed in a deep cavity, beyond which the seta only projects, head beneath black; thorax pale yellowish before, reddish-brown and rugose with continuous lines behind, anterior edge elevated, reddish-brown, a reddish-brown transverse band on the middle; scutel pale reddish-brown; hemelytra varied with fucous and pale, generally forming a band on the middle which is more distinct on the costal margin, spot at tip and larger one at base; nervules dark-brown; feet black, joint whitish; tibiæ and tarsi whitish, posterior tibia bi-spinous behind, of which one is very robust; length rather more than one-fifth of an inch.

The band of the hemelytra is sometimes indistinct, three brown dots near tip; female generally paler, with the abdomen whitish.

This species presents a remarkable number of quite distinct sub-species and varieties, and, owing to the fact that Say's description was of an extreme variety, a great deal of confusion has existed as to its limits, resulting in quite a number of these varieties being described as distinct species. I have appended these descriptions and have retained their names for the sub-species, except *testacea* and *pini*, which I find to be simply varieties of a sub-species of which the description of *osborni* is more nearly true; and it is therefore retained in preference.

The following synopsis of the species is a result of a summary of the different descriptions, and the study of 200 specimens representing every state given below with the exception of New Jersey. I am reasonably confident that with the possible addition of a few more varieties, it will stand the test of any farther discovery of material:

Large; front broad, flattish, with about nine bands above; second apical cell rectangular, elongate; pronotum finely, sharply wrinkled.

Front rising gradually from face at sides, making an obtuse angle with vertex above, upper portion light with about nine parallel, equidistant, transverse, interrupted, brown bands. Vertex very strongly, transversely depressed, carinated anterior margin prominent; suture between vertex and front distinct; ocelli situated near front margin.

Pronotum with about nineteen minute distinct wrinkles. Hemelytra minutely punctured, with a fine thickly set pubescence; second apical cell rectangular, elongate. First, discoid cell curved, narrower than second. Legs stout; spurs, spines and third tarsal segment tipped with black.

Length, four and one-half mm., width of pronotum, two mm.

Sub. sp. I. *obtusa.* Lower half of face fuscous or black.

Var. *a.* Dark; a distinct oblique, light band on hemelytra; pronotum, anterior half, light yellow, divided by a transverse brown band.

Habitat: Iowa, New Hampshire, Massachusetts, New York, Maryland, District of Columbia, West Virginia, Ontario, Canada.

Var. *b.* Light; same markings as above, only much lighter and less distinct.

Habitat: Iowa, New York, District of Columbia.

Var. *c.* Dark; hemelytra coppery; thorax without band; pronotum yellowish (*achatina*).

Habitat: Pennsylvania.

Sub. sp. II. *lineatocollis.* Lower half of face dark with a light band crossing the middle.

Var. *a.* Pronotum entirely dark; scutellum yellow; legs light with lateral dark lines. California.

b. Pronotum, posterior half dark, anterior half sulphur yellow; lines on femur and tibia broad, almost confluent. Colorado.

c. Pronotum light yellow, narrow brown band anteriorly; legs light, lateral line faint; dark band on clypeus reduced to a dot; hemelytra pale rufous, nervules brown, very distinct West Virginia, District of Columbia.

d. Pronotum entirely sulphur yellow; hemelytra dark coppery; legs brown. Maryland, District of Columbia.

Sub. sp. III. *osborni.* Face entirely light, bands on front obscure.

Var. *a.* Light olive green; scutellum sulphur yellow. Colorado, Wisconsin, West Virginia, District of Columbia.

b. Copper colored throughout (*testacea*). New York, West Virginia, District of Columbia, New Jersey.

c. Black; posterior margin of vertex, anterior margin of pronotum, costal margin of hemelytra, and legs yellow. (*Pini*) North Carolina, District of Columbia, New York (Fitch).

The following original descriptions may assist in recognizing the corresponding sub. sp. and varieties. Var. *a*, under each sub. sp., being its type, and of course the only one to which the description will entirely apply.

C. achatina.—(Germ. Zeit. fur Ento. Vol. I, 167.) Testacea, fronte nigra, elytris ante apicem fuscis, macula submarginali ante apicem nigra, femoribus medio fuscis. Hab. in Pennsylvania, Zimmermann. Two bis 2¼ lin. lang, rothgelb oder grau gelb, stirn und Mittlebrust, bisweilen auch der Hinter-theil des Bauches schwarz. Deckschilde von der mitte weg bis vor die Spitze Schwarzlichbraun, doch bleibt ein Fleck am Seitenrande hell. Die Ader des vorderrandes fuhrt vor ihrer Spitze einen schwarzen Fleck.

C. lineatocollis. Stal. (Eng. Resa, Omk. jord. IV, 286.) Caput dilute flavescens, verticis marginibus basali et apicali lineisque transversis frontis apicem versus longitrorsum impressæ nigrofuscis. Thorax postice

profunde angulatosinuatus, medio longitrorsum carinatus dilute flavescens, lineis pluribus tranversis fuscis ornatum. Tegmina latitudine vix duplo longiora, sordide flavescente-pellucida, medio fascia antrorsum augustata et abbreviata albida, anterius a linea, posticea fascia indistincta fuscis terminata, callo rotundato fere apicali ad marginem costalem nervisque apicalibus hic illic fuscis. Subtus nigro-varia. Pedis dilute flavescentes, vitta femorum maculisque tibiarum nigro-fuscis.

C. osborni Gillette. (List Hem. Col. p 71) Female: face two-thirds wider than long, minutely, indistinctly sculptured; clypeus broad at base, gradually tapering to the pointed apex, one-fifth longer than broad, basal suture obsolete; loræ long, nearly as long and half as broad as clypeus; genæ narrow, outer margin concave beneath eyes, convex below loræ where they are very narrow, touching the clypeus at the broadest part; front but little longer than broad, superiorly very broadly and evenly rounded. Vertex very slightly transversely depressed, anterior margin carinately elevated, not longer at middle than at eyes. Pronotum transversely wrinkled, minutely scabrous, two distinct pits behind anterior margin near the median line, three-fourths wider than long, anterior curvature three-eighths of length. Scutellum finely and transversely wrinkled and minutely scabrous, longer than head and pronotum, twice longer than wide. Elytra with a fine, thickly set, golden pubescence, entirely finely, densely punctured. Color pale rufous throughout, tinged with olive green on pronotum and clavus, beneath more yellowish. Length, five and one-half mm. Described from two females. Large but somewhat narrower across the hemelytra than is usual in this genus.

C. testacea Fitch. (Ninth Rep. St. Ento N. Y., 393.) Testaceous; scutel rufous; elytra with a polished callous-like black dot near the apex. Length, 0 20 inches

C pini Fitch. (Ninth Rep. St. Ento. N. Y., 393.) Black; head yellow, with a black band on the anterior margin of the vertex; thorax with a yellow band anteriorly; elytra with a broad hyaline under margin interrupted in the middle and a black callous dot near the apex. Length 0.14.

NOTE—I have been unable to obtain specimens of *C. undulata* and *C. stolida* of Uhler from the West Indies, but from their descriptions I am very confident that they will be found to be varieties of *obtusa* also. So that, with the possible exception of *C. brevis*, Walker, this paper includes all the present known or described forms of the North American Clastoptera.

GEOGRAPHICAL DISTRIBUTION.

Quite a number of interesting facts have been brought to light through a comparative study of geographical distribution. Each species possesses a wide range, while some of the varieties are exceedingly sectional in their distribution. As a whole *obtusa* has the greater range, occurring from Massachusetts to California, and from Canada to Georgia, and probably to the West Indies. Sub-sp. I, *obtusa* is the most common form in the east and the only one found in the Mississippi valley,

while of sub-sp. II, *lineatocollis*, var. *a* and *b* occur only in California, Arizona and Colorado, and var. *c* and *d* have only been reported from Maryland and West Virginia. Sub-sp. III *osborni*, var. *a*, has a wide range, while var. *b* (*testacea*) and *c* (*pini*) are only found on the eastern coast from New York to North Carolina.

C. proteus, sub-sp. I, *flava*, is found throughout the northern half of the Mississippi valley and the eastern states up to Canada, while sub sp. II and III, *vittata* and *nigra*, are found only in Pennsylvania and the surrounding states. Both varieties of *xanthocephala* have the same wide range: the southern part of the United States, from Maryland to Iowa on the north to Florida and Texas on the south. *C. delicata* with all of its varieties ranges from Colorado to California, and from Utah to Arizona.

ECONOMIC IMPORTANCE.

As a whole they are of considerable economic importance. Although not usually occurring in sufficient numbers to be noticeably injurious, however, *proteus* has been reported as having done considerable damage to cranberry swamps in a number of instances. Their food habits have not been very accurately determined. In general they feed on the sap of trees and shrubs, occurring most abundantly in low places. They have been reported as occurring on the ash, oak, pine, alder, butternut, elder, blueberry, cranberry and some of the larger grasses and weeds.

SUMMARY.

The study of this genus just recorded only adds one more instance to the many giving evidence against the immutability of species. Here we have four species, of which the larger and lighter varieties are widely separated, and easily recognizable by constant and strikingly distinct color markings, while at the other end of the series are small dark forms only capable of separation and recognition by reference to structural characters rendered indistinct by deep coloration. To still more complicate matters, *proteus* excepted, they have intermediate light green or glaucus forms which so grade into each other in size and shade that it is only on structural characters in general, and the shape of the apical cells, in particular, that they can be separated.

The structural characters upon which the species have been founded have proved so constant, within measurable variations, for all the different varieties, that I am confident the species and the synonymical determinations will stand. The limitation of sub-species and varieties, while as accurate and complete as the 400 specimens of available material would allow, will doubtless undergo some expansion and correction with the accumulation of new and larger collections of material.

In conclusion I wish to acknowledge indebtedness to Messrs. Gillette, Lintner, Ashmead, Weed, Fernald, Goding, Skinner, Van Duzee, Sirrine, Mally and Gossard and Miss Beach for the privilege of examining material, and for other favors extended, and to Professor Osborn, in particular, for the use of his private collection and the department material, and for his invaluable counsel and advice.*

EXPLANATION OF PLATES.

PLATE XI.

Figure 1. *Clastoptera obtusa*, Say.
Color markings of Sub-species I. *obtusa*.
Showing color markings of faces.
Figure 2. *C. obtusa-obtusa.*
Figure 3. *C. obtusa-osborni.*
Figure 4. *C. obtusa-lineatocollis.*
Figure 5. *C. proteus-nigra* (variety *b.*).
Figure 6. *C. proteus* Fitch.
Figure 7. *C. xanthocephala* Germ.
Figure 8. *C. delicata-lineata* (variety *a.*).

PLATE XII.

Venation of upper and under wings represented by one species from each genus as a type. The venation seems to be very constant within generic limits, as far as I have had opportunity to examine, with the exception of *Philænus* which either possesses two types or else there is another as yet unrecognized genus represented in our fauna.

Figure I. Wings of *Monecphora bicincta*, Say.
Figure II. Wings of *Philænus* sp.
Figure III. *Lepyronia 4-angularis* Say.
Figure IV. *Aphrophora quadrinotata*, Say.
Figure V. *Philænus* sp.
Figure VI. *Clastoptera obtusa*, Say.

* This work has been done in the entomological laboratory of the Iowa Agricultural College, and submitted as a graduating thesis.

PLATE XIII.

Figure 1. Leg of *Aphrophora quadrinotata*, Say, showing double row of spines.
Figure 2. Leg of *Lepyronia quadrangularis*, Say.
Figure 3. Leg of *Clastoptera proteus*, Fitch, showing single row of spines.
Figure 4. Side view of *C. delicata*, Uhl., showing outline of face. Oblique dorsal view of same showing inflation of front.
Figure 5. *C. proteus*, Fitch, same as above.
Figure 6. *C. xanthocephala*, Germ.
Figure 7. *C. obtusa*, Say.
Figure 8. Venation of hemelytra, *C. delicata*.
Figure 9. Same for *C. proteus*.
Figure 10. Same for *C. xanthocephala*, Germ.
Figure 11. *Clastoptera obtusa*, Fitch.
1, 2 and 3; first, second and third apical cells, a and b; first and second discoid cells.

PLATE XIV.

Figure 1. Abdomen of *Lepyronia quarangularis* Say, male, ventral view.
Figure 2. Female, of same.
Figure 3. Male, dorsal view.
Figure 4. Abdomen of *Aphrophora parallela*, Say, male, ventral view.
Figure 5. Female, ventral view.
Figure 6. Same, dorsal view.
Figure 7. Abdomen of *C. obtusa*, male, posterior view.
Figure 8. Female, same view.
Figure 9. Abdomen of *C. xanthocephala*, Germ., male, posterior view.
Figure 10. Female, same view.

OBSERVATIONS ON THE CICADIDÆ OF IOWA.

HERBERT OSBORN.

The members of this interesting group of insects, which contains the largest of our native Homoptera, have at least four representatives in the state of Iowa and it is the intention to call attention to these in this paper and also to put on record some observations regarding their habits and distribution which may serve as a basis for further investigations concerning them.

Cicada dorsata Say. One specimen of this large species in the collection of the Iowa Agricultural College from a student who stated that it was taken in Poweshiek county, is the only example indicating its occurrence in the state.

THE DOG-DAY CICADA.

(*Cicada tibicen* Linn.)

This is our larger common species, and one which, by its penetrating note, renders itself a conspicuous feature of the autumn weeks. First described by Linnè it has since received various appellations *Operecularis*, Olivier; *Pruinosa*, Say; *Lyricen*, DeGeer and *Canicularis*, Harris. This synomony arises partly on account of the variability of the species. This variation is considerable when its range over a large part of the United States is considered, but within our own state this variation is somewhat limited. Specimens collected here generally conform closely to the description given by Say for his *Pruinosa*.

Its distribution is quite general and I assume that it occurs throughout the eastern part of the state, at least, and in general over the timbered portions. I am assured by good observers, however, that there are places in the northwest part of the state where it is unknown. Specimens have been collected or received from many widely different localities.

In spite of its abundance and wide distribution our knowledge of its habits and life-history is very meager, though it is stated to require two years to complete its growth and to deposit its eggs in apple trees as one at least of the plants it may injure.

THE PERIODICAL CICADA OR "SEVENTEEN-YEAR LOCUST."

(*Cicada septen-decem* Linn.)

The "seventeen-year cicada" is doubtless the most interesting of all the Cicadas on account of its phenomenally long larval life. As is well known it lays its eggs in twigs of various trees and the larvæ entering the ground feed upon the roots of plants, and require a period of seventeen years to complete their growth. Two broods are represented in the state.

Brood V, Distribution.—In 1883, the locust year for the eastern part of the state, I secured, through the state crop service, reports from many of the localities which gave decidedly useful information with reference to limitations of the brood and comparison with previous occurrences. Records were received from over thirty counties and about ninety correspondents.

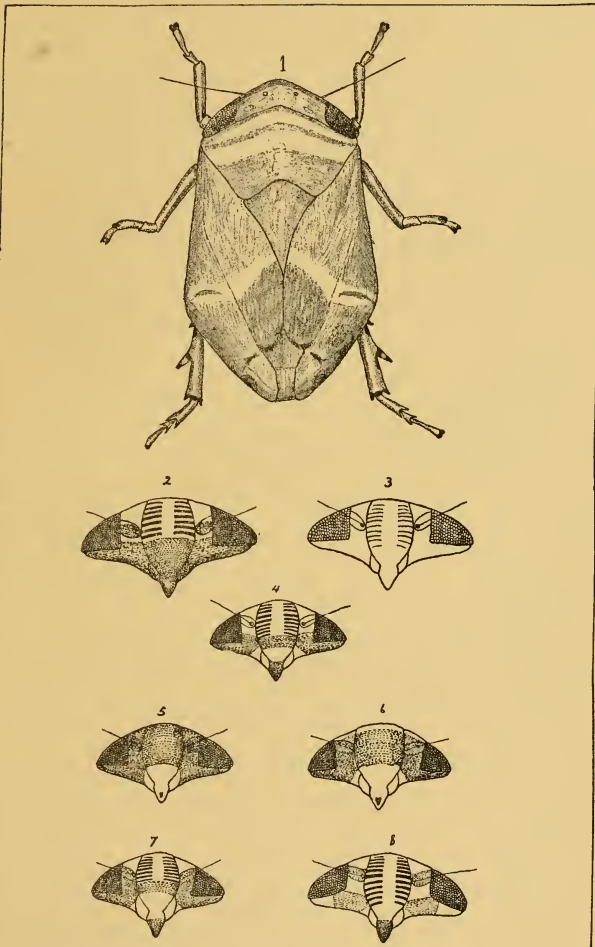
The limits of this brood have been outlined heretofore by Mr. Suel Foster, Dr. William LeBaron and Prof. C. E. Bessey.

Dr. LeBaron (2d Rept. Ill. Insects p. 130) writes as follows: "In the Prairie Farmer for July 29th, a brief outline of the locust range was published by Mr. Suel Foster, of Muscatine, Iowa, but in this outline, as Mr. Foster himself stated, many gaps were left undetermined. I have found Mr. Foster's outline to be, in the main, correct, and have filled, as far as possible, the gaps which he left. I will take the same starting point with Mr. Foster, namely, the junction of the Iowa River with the Mississippi in Louisa county, Iowa. Thence, in a northwesterly direction, following the eastern branch known as the Cedar River as far north as about opposite the mouth of the Wisconsin river. Thence east in about the same line of latitude to Lake Michigan, following the Wisconsin river so far as it lies in this line, thus leaving out the northernmost counties of Iowa and the two lower tiers of counties of Wisconsin." The rest of the description refers only to territory outside of Iowa.

In 1878 at the time of the occurrence of Brood XIII in southern Iowa, Prof. C. E. Bessey, then of the Iowa Agricultural College, collected data for the determination of the boundaries of that brood and incidentally collected considerable information concerning the distribution of Brood V in the eastern part of the state.

His report upon this investigation appeared in the American Entomologist, Vol. I. N. S., p. 27. As there given the area included is considerably greater than that outlined by Dr. LeBaron. He does not seem to have noticed the record of LeBaron given above. His outline is as follows:

Starting at nearly the same point in Wapello, Louisa county, the line he draws extends more to the westward, including the western or Iowa branch of the Iowa river as far west as into Tama county, and considerable territory to the southward, including all of Johnson, more than half of Iowa and a portion of Poweshiek counties. From Tama county northeastward to the extreme northeast corner of the state including nearly all of Black Hawk, Fayette and Allamakee counties, and part of Bremer, Chickasaw and Winneshiek, with a possible extension westward so as to include all the counties to the north and east of Tama, though reference to his notes indicates some of the counties included, as Allamakee, Winneshiek, Black Hawk, Fayette and Bremer to be doubtful.



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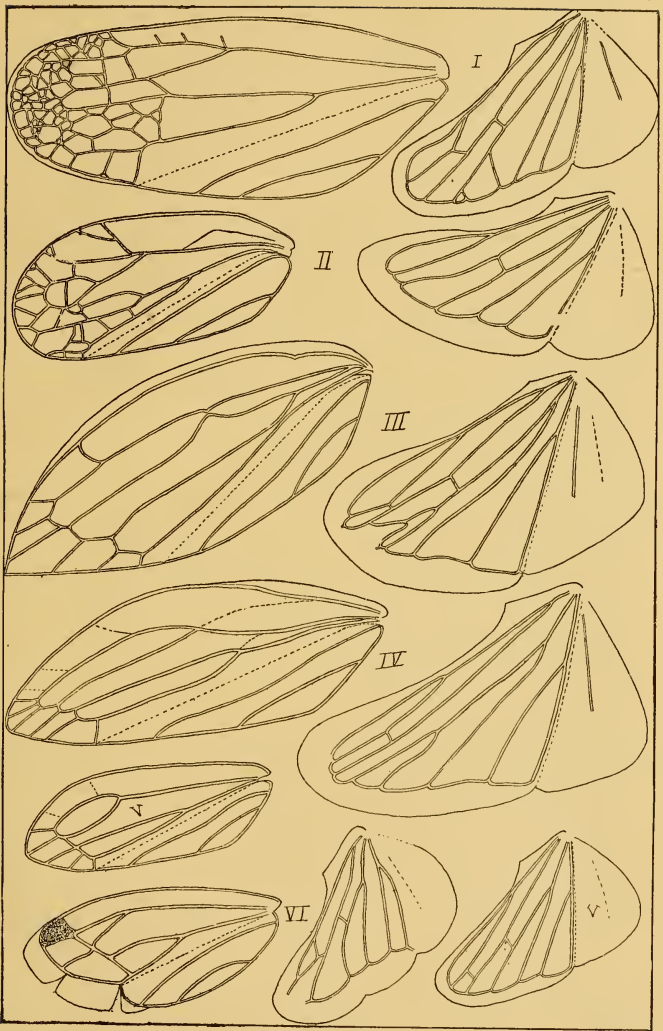

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The counties reporting Cicadas for 1888 are as follows: Benton, Black Hawk, Buchanan, Clayton, Clinton, Cedar, Delaware, Dubuque, Iowa, Jackson, Johnson, Jones, Louisa, Muscatine, Scott, Tama. This shows only the counties reporting but does not indicate the extent or distribution in the counties, and this, for the border counties particularly, is quite important in fixing a definite boundary. I took pains therefore to locate the particular township from which the reports came, which was possible by examining the records at the secretary's office in Des Moines, and was thus able to locate the actual boundary usually within six miles at most, certainly within the limits of the ordinary flight of the insect.

The line of townships beginning at the Mississippi river in Muscatine county and naming those on the border line from which positive reports were received is as follows: Muscatine county, Fruitland, Cedar; Louisa county, Columbus City; Iowa county, York, Summer; Benton county, Saint Clair; Tama county, Clark, Geneseo; Black Hawk county, Spiny Creek; Buchanan county, Sumner; Clayton county, Cox Creek, Clayton.

For convenience sake we may carry our line through the towns and villages nearest this line and it will be approximately as follows: Fruitland, along south line of Muscatine to Columbus City, then along the west of the Iowa river till in Johnson county, then northwest to York Center, Iowa county and to near Ladora, then northeast to Blairstown, then northwest to Dysart, then northeast through Laporte City, Independence, Strawberry Point, Elkader and Clayton.

The area of natural timber corresponding for the most part with the valleys of the rivers and smaller streams, the distribution of Cicada may be pretty accurately expressed by defining them, and on this basis they may be said to occur in the valley of the Iowa river from Columbus City to west of Marengo, in the valley of the Cedar river and its tributaries as far to the northwest as Laporte City. In the Wapsipinicon to Independence, in the Maquoketa to Strawberry Point, in the Turkey to Elkader, and north on the Mississippi from south central Muscatine county nearly to McGregor.

Numerous reports not specially indicated, attest their abundance in all the central counties of this area and need not be specified but some which bear particularly upon the border line may be quoted here.

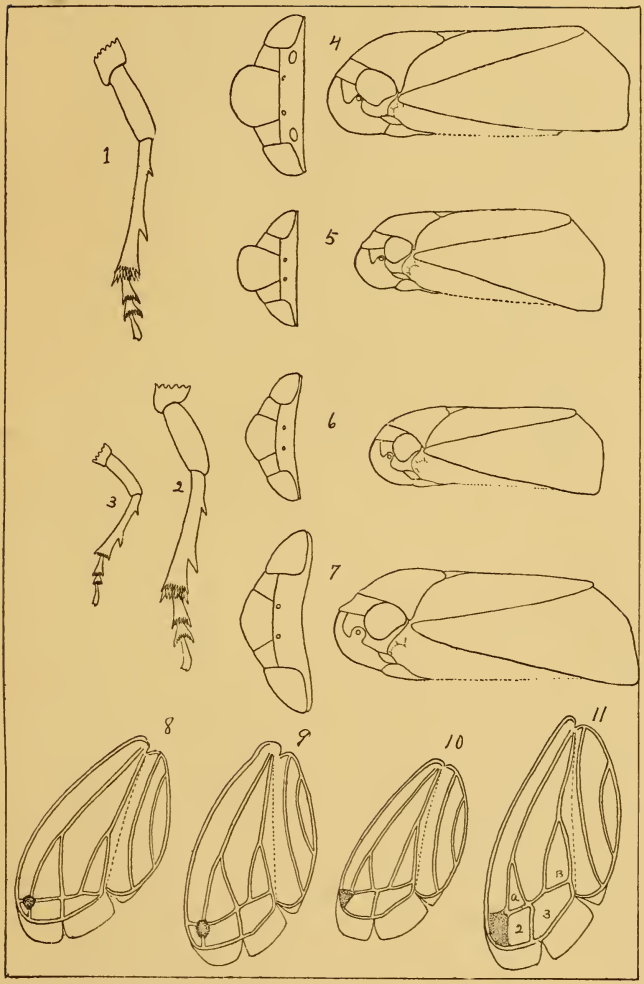
Mr. V. C. Gambell, a student in entomology whose home was at Winfield, in Henry county, saw no locusts there but a man in that vicinity reported hearing them and had seen one shell. This is rather uncertain testimony especially in view of absence of reports from this and the adjoining county to the north. If correct it shows a very feeble representation of the insect there. Mr. Gambell noticed in traveling on the Chicago, Rock Island & Pacific railroad from Brooklyn to Iowa City that the trees were injured, apparently by Cicada. If all due to Cicada this would carry the brood into Poweshiek county several miles further west than indicated by other reports.

Mr. E. N. Eaton of Keota, in the extreme east of Keokuk found no locusts and no reports of them for that county.

Mr. P. H. Rolfs reports for the central eastern border of Tama county that there were no locusts and none for about five miles to the east of the county line, while Mr. F. A. Sirrine reports for a point about six miles further north that locusts were in Tama county, two miles west of the county line in Geneseo and Clark townships, but not in townships west so far as he could learn.

The following additional statements from correspondents have a special significance in determining the border line:

Louisa county, Wapello township, "None; a few in north part of the county." Columbus City, "Locusts present." In Keokuk county, Clear Creek township, "None here this year, but here seventeen years ago." Prairie township, "None yet; were here seventeen years ago." Garman township, "No locusts, last in 1877" [1878 Brood XIII probably]. Iowa county, York township, "Locusts in limited numbers in northeast third of this township." Poweshiek county, Malcom township, "None." Sheridan township, "None." Bear Creek township, "None. None seventeen years ago." Warren, "None yet, July 15th. Were here sixteen and seventeen years ago; second year in great numbers and did great damage to fruit trees and shrubbery." Chester township, "No seventeen year locusts to amount to anything; appeared in 1861 and 1878." [Brood XIII]. Black Hawk county, Spring Creek township, "Yes, and seventeen years ago." East Waterloo township, one correspondent says: "No, never here." Another says: "No. A few seventeen years ago." Fayette county, Westfield township, "None;



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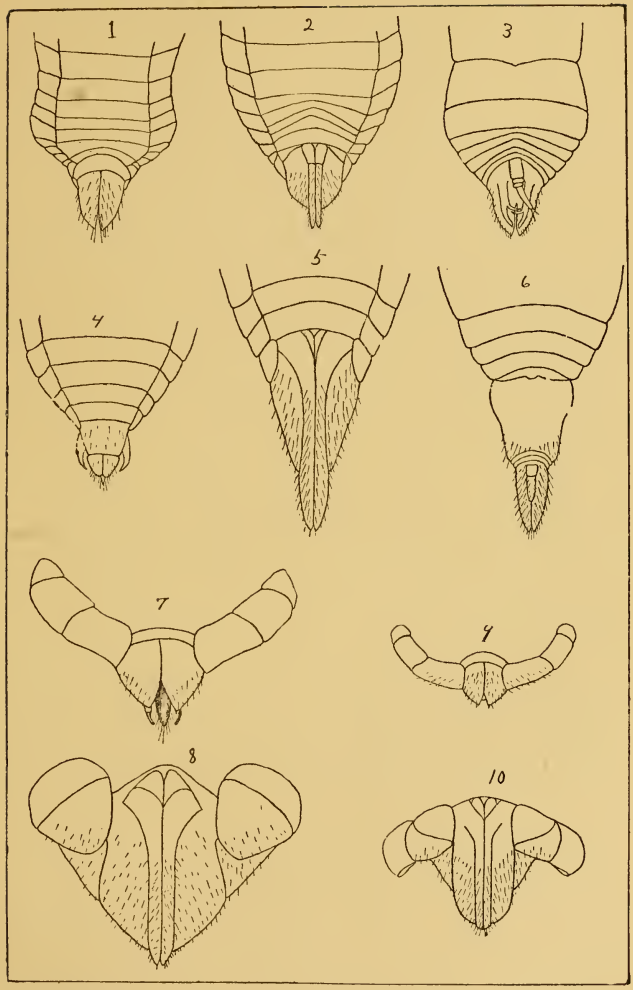

E. D. Ball, del.

none seventeen years ago." Eden township, "None." Jefferson township, "None within thirty-four years to my knowledge." Clayton county, Giard township, "None this year; a few seventeen years ago."

Brood XIII.—Professor Riley (1st Ann. Rept. State Entomologist of Mo.) mentions this brood as occurring along the southern border of Iowa, but does not specially define its limits. The 1878 occurrence was studied by Professor Bessey and the data collected enabled him to define the limits of the brood with considerable exactness (Amer. Entom., N. S. Vol. I, p. 27).

According to this record they occurred in the following counties: Van Buren, Davis, Wayne, Decatur, Des Moines, Henry, Jefferson, Wapello, Monroe, Union, Louisa, Keokuk, Mahaska, Marion, Warren, Madison, Adair, Cass, Iowa, Poweshiek, Jasper, Polk, Dallas, Marshall, Story, Boone, Greene, Hamilton, and they were assumed to occur in the counties embraced within the area encompassed by these, Clarke, Appanoose, Ringgold, Washington, Johnson, as indicated on his map, outline of which is shown. (Plate XV.)

On the recurrence of this brood last season (1895) I published requests in a number of state papers and also obtained from students and others, data covering as much territory as possible. The responses to the published requests were not so general as could be wished. In some cases many reports coming from the same locality, while a number of counties, where they must have occurred, furnished no reports.

Taking the counties reported in their order from the eastern border of the state they run as follows: Louisa, Keokuk, Poweshiek, Tama, Marshall, Story, Webster, Boone, Dallas, Madison, Union, Decatur, and for counties within the outer limits, Polk, Jasper, Marion, Monroe, Wapello, Jefferson, Van Buren, Lee.

The counties within this area which must, in all probability, have been visited, are Warren, Mahaska, Lucas, Wayne, Appanoose, Davis, Washington, Henry, Des Moines, while the doubtful ones are Johnson, Iowa, Hamilton, Greene, Guthrie, Adair, Ringgold.

Reports from Iowa and Johnson are quite positive as to their non-appearance in those counties, though it is possible our informants could speak for only a part of the area. There is also a probability that they occurred in Hamilton county, close to the Des Moines valley at least, if not in the Skunk.

In Greene, Guthrie and Adair they may have occurred in the valley of the Raccoon or tributaries.

By river valleys, then, which give really the more important distribution, we can say that they appeared in the Iowa valley at Louisa county, were absent or possibly scarce in Johnson and Iowa counties, but present in Tama and Marshall and north as far as Marshalltown; in the valley of the Skunk river from its mouth to Ames in Story county; in the valley of the Des Moines and its tributaries as far north as to near Fort Dodge and Lehigh, and in the Raccoon in Dallas county; also in the valley of the Grand river and its tributaries in Decatur, Union and Clarke counties.

Comparison of the points giving actual occurrence in 1895, represented on our map by square black spots, with the outline of Professor Bessey's map shows a reduction in most of the outline, with a slight extension in the Des Moines valley. These reports on the whole would suggest a reduction of the area, and many of the reports state a reduction in number of cicadas as compared with previous occurrences.

It is of course impossible with the records for even three or four occurrences to draw any conclusions as to the future history of the insect or assign causes to any apparent changes, still some suggestions as to probable influences may not be out of place as indicating lines of future observation and record. It is evident that many years must elapse before the problems connected with the species can be properly discussed.

Admitting that the broods in these respective areas have declined, it is interesting to inquire into the possible conditions affecting the perpetuation of the species.

It should be borne in mind that the great bulk of settlement in these parts of the state occurred between the appearance of the broods in 1854–1871 and 1861–1878 respectively, and that the settlement resulted in some important changes of the timber distribution. These changes took two forms, first a diminution of the natural timber belts along the streams from the necessities for fuel and in much less degree the clearing of limited tracts for cultivation. Second, an extension of the timbered area by the planting of groves, wind-breaks, orchards, etc., on the treeless portions. The former I believe not to have affected the area or quantity of timber very greatly, as it would be made good by the natural growth and extension and, especially as regards the Cicada, had, I believe very little influence. The

latter, though perhaps having very little effect as increasing the actual quantity of timber, seems to me a much more important factor in connection with the Cicada problem. These insects show a very decided tendency to deposit their eggs in young trees, and in 1871 and 1878 found abundant opportunity in the numerous young orchards and groves developed since their prior occurrence to satisfy this propensity, so much so that they must have in many places deserted in no small degree the natural timber areas for these artificial ones.

Now, it seems natural to suppose that depending normally for their food on roots common to areas of natural timber they should have been met with a deficiency of such food in many of the localities to which the adults had flown to deposit eggs, and consequently have failed to develop and mature.

Such an influence will, of course, not be permanent and if this be the only factor of importance Cicada should recuperate in the future.

It has been my privilege to observe personally the occurrences of both these broods since 1871, and I hope to have the opportunity to observe many of their generations in the future.

OTIBICEN RIMOSA, SAY.

This species, which may be considered as belonging more particularly to the northern and western fauna, is represented in this state by a depauperate form and in the northern and western portions by a form more closely approaching the western type.

It was described by Thomas Say in Proc. Acad. Nat. Sci. for 1830, p. 235, who ascribes it to the Missouri and Arkansas and says further "Mr. Nuttall presented me with two specimens which he obtained on the Missouri, and I found one on the Arkansaw."

While Mr. Nuttall's specimens may have been secured on Iowa soil the probability seems strongly in favor of a location further west in the then extensive territory of Missouri.

But slight mention has been made of the species since that time and if it is found in the Mississippi valley as a species at all common, it has failed to receive due mention. It is collected in abundance in the Rocky Mountain region, and I have numerous specimens from Colorado and New Mexico.

Aside from the depauperate form to be mentioned further, I have specimens from Tama county, collected by Mr. F. A.

Sirrine, of the larger form approaching typical examples also from Worth county, collected by Mr. S. W. Beyer.

It occurs somewhat commonly in the northwest part of the state and probably is responsible for some of the reports of seventeen year Cicada emanating from that quarter. Mr. E. D. Ball, a graduate of the Agricultural college and whose home is at Little Rock, Lyon county, states that it is found quite abundantly throughout the prairie regions of the northwest part of the state and that it was more abundant in the 70's, before the prairies were broken up, than at present. He gives some interesting observations regarding its habits, the most striking being that it occurs on prairie land remote from timber, thus indicating a habit quite different from the other members of the genus. He states that in herding cattle on the ranges years ago, he has seen them as many as four or five to the square rod of grass in localities where the nearest trees were ten miles away and these only bush willows fringing a stream. During the summer of 1893 he carefully observed them in a lot in town. The lot was bordered on two sides by a double row of trees, box-elder and maples. At any time plenty of the cicades could be found or heard in the grass, but careful searching failed to find a single one or any indications of egg deposition. They occur more abundantly in the rich upland grass at the foot of a hill or bordering a meadow, a situation equally favorable to the growth of certain prairie weeds, notably the "shoestring" or Lead plant, *Amorpha canescens*, which has a very tough woody stem, a plant which was particularly abundant in the lot above mentioned. The cicadas were frequently seen on this plant, but no eggs were found. They appear the latter part of June and only live for two or three weeks at most.

The form of this species which occurs at Ames is much smaller and with more extensive orange markings than in the western forms; it is by no means common and no observations have been made as to its breeding habit here. It is so different from the larger Rocky Mountain form that were it not for the intermediate forms occurring throughout the range of the species as a whole, there would be little question as to its being recognized as distinct. This form agrees with the one described by Emmons as *noveboracensis*.

MELAMPSALTA PARVULA SAY.

This interesting little species has been taken once at Ames and this is, so far as I know, the only record of its occurrence in the state. It is a more southern form, being credited to the southern states as far north as southern Illinois and central Kansas. Very likely it may be found occasionally in the southern part of the state when collectors become more plentiful.

Any addition to these records will be gratefully received and duly credited in future records.

BIOLOGIC NOTES ON CERTAIN IOWA INSECTS.

HERBERT OSBORN AND C. W. MALLY.

The following notes are extracted from Bulletin 32 of the Iowa Experiment Station, and embrace such portions of work upon certain injurious insects as have a biologic interest. We are indebted to the Experiment Station for the use of the figures.

THE GROUND CHERRY SEED MOTH.

(*Gelechia sp.*)

Our attention was called to this insect by Dr. J. C. Milnes, of Cedar Rapids, who reported it as very destructive on wild ground cherries under cultivation; writing further, that this cherry being very prolific and of excellent quality would be a desirable garden plant were it not for the great injury from this pest. The specimens sent contained the insect in the pupa stage.

Cultivated ground cherry at Ames suffered from similar attack, and the pest seems likely to occasion much loss.

Examination of wild ground cherries in the vicinity of Ames revealed a considerable injury from the pest, and steps were taken to secure the early stages and determine as fully as possible the habits of the insect.

Out of 1,000 berries examined 130, or 13 per cent were infested. All of these infested berries contained the pupæ enclosed in a white silken cocoon which filled most of the cavity of the berry, the seeds being entirely devoured. Near the stem end of the berry and opposite the head of the pupa was an opening presumably prepared for the emergence of the moth.

Observations on these berries would favor the conclusion that the larvæ develop within a single berry, no injured berries being found which did not contain pupæ. However, two berries were found with an opening on the side and containing well developed larvæ with very little of the inside of the berry devoured, suggesting that the larvæ, under exceptional conditions migrate from a berry of insufficient food material to a fresh one.

But very few larvæ were found and these during the last week in September. They were at that time mature and apparently ready to pupate; so of the early molts and even of the full grown larvæ we cannot give a satisfactory description. Those observed were rather contracted, spindle-shaped, whitish, with a reddish-brown head, sparsely haired.

Pupation occurs during last two weeks of August and is in nearly all cases completed by the last of the month.

The pupæ are dark brown, six mm. long, and no distinctive characters that would separate them from related species were detected. The cocoon is thin but of tough, close woven silk. In forming the cocoon the larva attaches itself to the blossom end of the berry by means of the caudal prolegs and then builds the cocoon which practically fills the cavity of the shriveled berry.

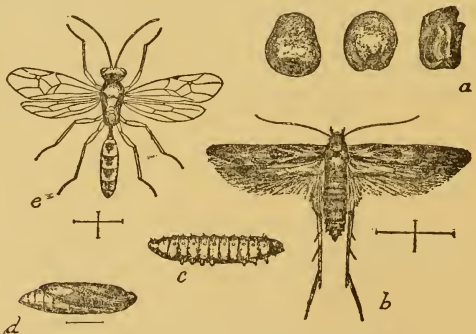

FIG. 1. (*Gelechia sp.*) *a*, injured berries. *b*, moth. *c*, mature larva. *d*, pupa. *e*, parasite *Centeterus suturalis*.

Moths first appeared October 3d, so the period of pupation may be stated as from two to three weeks.

The moth shown at *b* in Fig. 1 is of a gray color with darker spots on the wings. It closely resembles *G. quercifoliella.*

Out of the 130 berries containing pupæ mentioned above we secured four specimens of moths. This low per cent of adults is due to the fact that a large proportion of the pupæ, over 100, were destroyed by a fungus, apparently quite similar to Sporotrichum, and of the remainder a number were attacked by a Hymenopterous parasite (*Centeterus suturalis Ash*), seven of which issued prior to September 24th.

The fungus was not observed to attack healthy berries, always making its appearance after the hole had been made near the stem, and, while it seemed to develop in the tissues of the berry, there seems scarcely any doubt but that it is a parasite of the insect. Some of the Hymenopterous parasites issued from berries showing fungus growth, so that it would appear possible for these to resist the fungus, even when pupæ were infected with it; that is, supposing the fungus to infest primarily the *Gelechia*. Doubtless a parasitized larva would be a more easy victim of fungus attack.

The appearance of moths so late in the season, the impossibility of their producing another brood, and the improbability of their depositing eggs in any situation where they would winter and assure the larvæ access to their food plant the following spring, almost forces us to the conclusion that the moths hibernate and deposit eggs when ground cherries bloom the following season. This view is strengthened by the fact that a specimen was captured in an office room of one the college buildings December 7, 1894. Nevertheless, so long an existence of the adult for so delicate a lepidopterous insect seems doubtful, and the possibility of some pupæ hibernating or of a spring brood of larvæ, even in some situation different from the berries of *Physalis*, must not be overlooked.

This species, as already intimated, very closely resembles *G. quercifoliella*, and it was so determined with some doubt by Mr. Marlatt from specimens sent to Washington for identification. The fact that it affects a totally different plant indicates it to be quite distinct from that species. It is certainly different from *physaliella* as described by Chambers, and has a totally different larval habit, that species being said to mine the leaves of *Physalis* in September, to pupate in leaves and rubbish on the ground, and to issue as adult in April. Still another species described as *physalivorella* was thought possibly to represent our form, though no record of its larval characters or habits were accessible. Mr. Marlatt has, however, kindly

compared our specimens with three specimens of *physalivorella* in the National museum, and states, "these are very distinct from your specimen." "The latter agrees quite well with G. quercifoliella, but may be a distinct species."

From this it seems most probable that this insect is undescribed, but we prefer to leave the technical description to some specialist in this group of delicate and inetresting moths.

ON THE EARLY STAGES OF THE IMBRICATED SNOUT BEETLE.

(*Epicaerus imbricatus* Say.)

While this species has been recognized as a pest since its first economic treatment by Walsh in 1863, our knowledge of its life history has remained as meagre as at that time, nothing being known as to its early stages, except the record of egg laying by Professor Forbes.

This led us, on receiving specimens of the beetle with the report of their injury to strawberry plants, to attempt their breeding upon this food plant. While we did not succeed in tracing the full history of the species, the securing of eggs and the partial development of the larvæ, and the possibility that this clue may assist in the further elucidation of its history is our excuse for presenting this fragmentary account.

On May 14, 1895, the adults were placed on a strawberry plant having three or four open leaves and a number of small berries. They immediately crawled up the stems and soon began feeding upon the leaves, cutting a crescent corresponding to a line described by the end of the snout. The crescent was apparently quite uniform but soon became irregular when the beetle had to move in order to reach the tissue; so in reality there is no regularity in devouring the leaf and finally nothing is left but the veins and a few angular fragments of leaves. By the following day the effect on the leaves was quite apparent, the beetles eating rapidly, and by the 20th the leaves were all devoured except a few dry, curled pieces and the stems. They did not attack the berries, but in some cases ate the sepals at the base.

The beetles began pairing the first day and continued for five or six days. No eggs were observed till the 21st when a number of small, white, glistening eggs were found under a fold of a leaf and as no folded or dry leaves had been left on the plant these eggs had certainly been deposited by the *Epicaerus*. On the 22d another leaf containing eggs was found

LEGEND
BROOD V (BESSEY)
DOUBTFUL EXTENSION
LEBANON OUTLINE
BROOD XIII (BESSEY)
POSSIBLE XIV
V 1889 RECORD
XIII 1885 RECORD

and these, with those previously found, were placed by a fresh leaf that had been carefully freed from all matter that might possibly contain eggs of other species, and the beetles removed to avoid possibility of their injuring the egg. The eggs appeared in all cases to be protected by a fold of leaf carefully glued down.

FIG. 8. *Epicaerus imbricatus* eggs. (Drawn by Miss King.)

Forbes[1] says of *Epicaerus* that they "were found by experiment to feed freely on pear leaves, and also to lay their eggs upon these leaves, concealing their deposit by gumming another leaf to the surface."

The eggs are 1.3 mm. long, glistening white, nearly cylindrical, sometimes very slightly curved, the ends broadly rounded, the surface smooth, transparent and the shell very thin.

The first larvæ to hatch escaped before being seen, the empty shells being first noticed on the 30th. Hatching therefore occurs within ten days from time of deposition. Other eggs isolated and kept under close observation showed that the larvæ immediately work their way into the ground and these observed in root cages, during the following three weeks, could be seen to move about among the roots and as they very evidently increased in size and appeared to thrive it is safe to say that they fed upon the roots of the strawberry plant.

The death of the plants in the root cages and the loss of the larvæ unfortunately brought the observation to an end.

The young larvæ are two mm. long, without any trace of eyes or legs. They are yellowish-white in color, the head from above oval with a few strong bristles and the mandibles very conspicuous. The maxillary and labial palpi are short, stumpy and in the living larvæ stand out rather prominently from the under side of the head. The body segments are provided with a few small hairs.

[1] Sixteenth Report State Entom., Ill. p. 76.

Adult beetles have been observed in autumn, as early as August, but the probability is that only one brood occurs each year, the adults surviving the winter.

This fragmentary result enables us to say with certainty that the eggs are deposited in dry and folded leaves of the food plants of the adults and that the larvæ immediately enter the ground to feed upon the roots. To this extent they show what measures of control must be adopted for this insect.

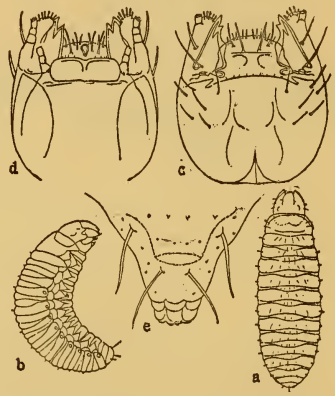

FIG. 9. *Epicaerus imbricatus*. *a*, *b*, young larva, back and side view. *c*, head above. *d*, head below. *e*, terminal segment. (From drawings by Miss King.)

THE COSMOS WEEVIL.

(*Baris confinis Lec.*)

This weevil, Fig. 4, was found September 1, 1895, to work very extensively in the root-stocks and the base of the larger branches of *Cosmos bipinnata* causing the ultimate destruction of the plant. The presence of the insect is first manifested by

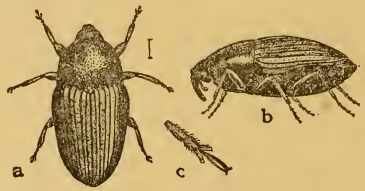

FIG. 10. *Baris confinis*. (Drawn by Miss King.)

the breaking off of the larger branches. By examining the base of these branches, and especially the root-stock, it will be

found that numerous white larvæ and pupæ about one-eighth inch long are present and working in the woody tissue of the plant. They make small tunnels, packing the borings around them much as does the potato-stalk-weevil. They pupate in these tunnels and emerge as a small black beetle.

The adult when first formed is white and takes on the black color gradually, beginning on the head and thorax and then extending backward to the scutellum and base of elytra and then gradually over the whole body.

The adults are quite active but drop to the ground as soon as disturbed and remain very quiet for some time.

Specimens of the adults kept on plants under observation in the laboratory worked in the young tender tissues, either eating into the terminal portions or into the stems at the axils of the leaves, almost burying themselves and finally causing the small leaf or branch to break down, as do the larger branches. They were not confined entirely to the parts just mentioned but would eat into the little leaflets as they were expanding, thus preventing their complete opening.

One individual was found boring into the end of a broken stem making its way into the pith and almost disappearing in a short time. It remained in that position for some time. Thinking that it might be a female and that the eggs were being deposited, the cavity was examined at the end of four or five days, but no eggs were found. This adult was placed on a growing plant and soon began feeding in the young tissues as stated above. On one small plant in the laboratory the young leaves were so badly eaten into that the plant died in a short time.

One specimen was taken while collecting in the woods August 31st. So the species undoubtedly infests other plants besides the one recorded above.

Nothing can be stated concerning oviposition and the early larval stages. As stated above, numerous fully grown larvæ and pupæ were found in the root-stock and base of the larger branches September 1st. A few fully colored adults were found a few days later. One root-stock was isolated during the second week in September and adults kept gradually issuing until about the middle of October. From this one root-stock as many as twelve to fifteen specimens issued besides the numerous larvæ and pupæ that were removed for the purpose of examination.

Since no eggs were deposited by the specimens kept under observation and adults were still very active after the plants

had all been killed by frost, it is quite safe to say that they hibernate and deposit eggs the next spring, there probably being but one brood each year.

A nearly related species, determined at the Division of Entomology, U. S. Department Agriculture, as *Baris dolosa* Casey, was bred in small numbers from the same stems. It was thought to be the same and differences in appearance due to imperfect maturing, but there is a decided difference in form of thorax and it seems probable that both species breed in the same plant and with practically the same life history.

DESCRIPTIONS.

Larva: Fig. 11, a. The fully grown larva is about 5-32 in. long and 1-16 in. diameter, and a yellowish-white color; head light brown, mandibles reddish-brown; legs represented by mammiform protuberances. The body tapers somewhat toward posterior end, the last segment usually showing four bristles.

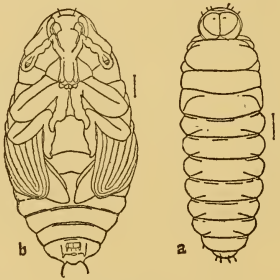

FIG. 11. *B. confinis*. *a*, larva. *b*, pupa.

Pupa: Fig. 11, b. About the same length as larva, but comparatively wider. Head (from beneath) fits closely to the body, eyes not especially prominent; antennæ wide in proportion to the length, normally not projecting beyond the sides of the thorax, club conspicuous, usually somewhat denser in appearance. Snout reaches base of first pair of legs and shows small, roundish portions at tip corresponding to the mouth-parts. First and second pair of legs clumsy in appearance; joints of the tarsi indicated, the last one distinctly curved; third pair of legs hidden, only a slight portion being visible along the inner margin of the hind wing-pads. Four abdominal segments visible for their entire width. The last segment usually has two apical bristles and a group of small spiny processes.

Adult Fig. 10. (a, dorsal view; b, side view; c, tarsus.) Widest at base of elytra and tapers strongly toward either end; shining black, glabrous; numerous medium sized punctures on the thorax and between the striæ of the elytra. Snout about 1-24 inch long, curved, usually extending directly downward, but sometimes drawn backward or slightly projected forward. Thorax narrows perceptibly toward the head. Tarsi strongly pubescent beneath, claws strongly curved, diverging. Elytra emarginate at tip, making the tip of abdomen more distinctly visible from above.

REMEDIES.

Collecting and burning the old root-stocks and stems in early autumn will be the most effective treatment that can be suggested from present knowledge of the species.

AN INSECT OCCURRING IN WATER TANKS AND RESERVOIRS.

(*Chironomus sp*)

Early in July I received some specimens of a slender red larva from Boone, with the following letter:

Professor Osborn:

DEAR SIR—Enclosed I send a sample of the worm that appeared in our city water about a week ago in countless numbers. Would like to know what they are and where they would be likely to come from. The water we use comes from a 3,000-foot well, but about two weeks ago our pumps failed and we were supplied with water from a forty-five foot vein owned by the C. & N. W. Ry. Co., and pumped to our reservoir through a hose.

Yours truly, E. E. CHANDLER,
Chairman Water Committee.

Boone, Iowa.

The larvæ were evidently *Chironomus*, and in replying to the letter it was so stated and that in themselves they could be considered harmless, though of course the presence of masses of such ugly looking creatures would be objectionable, and if dying in the water they might become a source of pollution Also that the larvæ must have gained access to the water from the eggs of the adult mosquito-like insect being deposited in the reservoir or the mains by which it was filled. They could not be derived from a deep well. It was suggested that provision be made to exclude the insects from the water to prevent deposition of eggs.

The larvæ (Fig. 12) *a* and *b*, which are an inch or a little more in length and of a light red color with green reflections on the sides near the head, construct a tube at the bottom of

the water in which they live, and in this remain protected and from it extend themselves to obtain food. The food is for the most part apparently minute aquatic organisms, algæ, etc. Their presence might be considered a means of clearing water of such matter did they not at times become so numerous as to prove an element of danger.

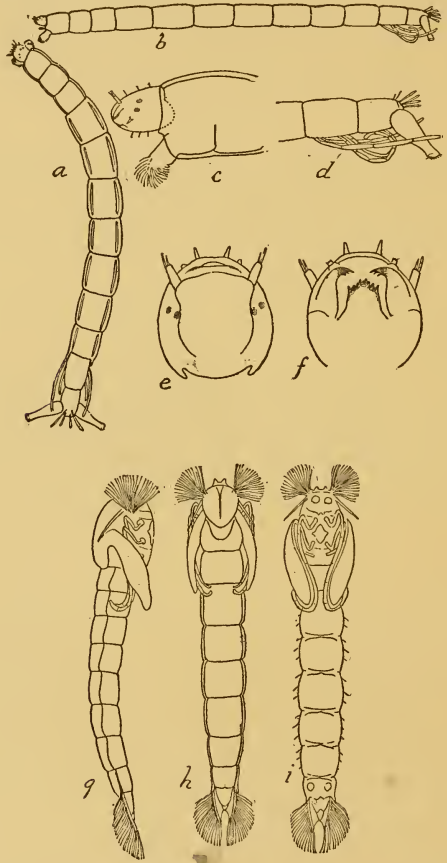

FIG. 12. (*Chironomus sp.*) *a*, larva, dorsal view. *b*, side view. *c*, head and first segments of body. *d*, terminal segments of body showing appendages. *e*, upper surface of head. *f*, lower surface of head. *g*. side. *h*, dorsal. *i*, ventral view of pupa. (Original, drawn by Miss King.)

Later in conversation with Mr. G. W. Brown, a civil engineer of Boone, it was learned that the water was pumped into a large cement-lined reservoir which contained the larvæ in immense numbers and was without question the point where the eggs were laid, it being exposed to easy access by insects. It appeared also that the larvæ were drained into the mains at times when the reservoir was low, doubtless causing strong currents over the bottom. Specimens have also been received from Des Moines.

When mature they change to a delicate pupa (Fig. 12, *g*, *h*, *i*,) and then rise to the surface of the water and soon the adult insect escapes from a slit along the back of the pupa case.

The adult is a delicate mosquito-like insect (Fig. 13.) belonging to the genus *Chironomus* but it cannot be referred to any of the described species and the present state of the classification of this genus is such as not to warrant us in giving it a scientific name or description.

FIG. 13. (*Chironomus sp*) *a*, adult male. *d*, antenna of female. (Original).

The insect is of interest at this time because of the great number of water tanks and reservoirs established, not only in cities and towns, but on many farms, and the probability of its frequent occurrence where these are open to visits of the adults.

Exclusion of the adults, where practicable, may be accomplished by the use of ordinary mosquito netting or wire gauze. Where this is impracticable the providing of an inlet to distributing pipes that will draw water from a few inches above the bottom of the reservoir (which might further be protected by a fine screen) will, it is believed, avoid the distribution of the worms in the mains.

CONTRIBUTIONS TO A KNOWLEDGE OF THE THRIPIDÆ OF IOWA.

ALICE M. BEACH.

This paper represents the results of a study of some of the Thripidæ of Iowa, and is based upon an examination of material found in the collection of the Iowa Agricultural College, some specimens kindly loaned by Miss Emma Sirrine, Messrs. F. A. Sirrine and C. W. Mally, and some in the writer's own collection. Descriptions of seven new species and three new varieties are herewith presented, including a new species of Phlœothrips described by Prof. Herbert Osborn. The descriptions are preceded by an artificial key, arranged to aid in the identification of all the described Iowa species known to the author. The table for the determination of genera is substantially that found in Comstock's Introduction to Entomology, pp. 125-127. The writer is indebted to Mr. Pergande for an outline of the characters of Euthrips, and is under special obligations to Professor Osborn for valuable aid in the prosecution of this work which has been done in the Entomological Department of the Iowa Agricultural College.

TABLE FOR DETERMINATION OF GENERA.

A. Last abdominal segment in both sexes elongated, narrow, tubular; both pairs of wings similar, veinless, margins equally ciliated; maxillary palpi two-jointed; borer in female absent ..... Sub-Order I. Tubulifera.

B. Contains but a single family ..... Fam. I. Tubuliferidæ.

C. Contains but a single genus ..... Gen. 1. Phlœothrips.

AA. Last abdominal segment not elongated and tubular in both sexes; both pairs of wings unlike in structure, front wings always veined; margins unequally ciliated; maxillary palpi three-jointed; borer in female present ..... Sub-Order II. Terebrantia.

B. Females with borer curved upwards ..... Fam. II Stenopteridæ.

BB. Females with borer curved downwards ..... Fam. III. Coleoptratidæ.

FAM. II. STENOPTERIDÆ.

A. Body above netted with elevated lines.....Gen. 2. Heliothrips.
AA. Body above smooth.
B. Abdomen clothed with silky hairs; apex conical, formed alike in both sexes.....Gen. 3. Sericothrips.
BB. Body smooth; apex of abdomen unlike in the two sexes.
C. Prothorax produced in front, and narrowed.....Gen. 4. Chirothrips.
CC. Prothorax not produced in front and narrowed.
D. Last segment of abdomen with a pair of spines in female; male, wingless.....Gen. 5. Limothrips.
DD. Last segment of abdomen unarmed.
E. Last two segments of antennæ shorter than the sixth segment.....Gen. 6. Thrips.
EE. Last two segments of the antennæ longer than the sixth segment.....Gen. 7. Belothrips.

FAM. III. COLEOPTRATIDÆ.

A. Antennæ with nine distinct segments.....Gen. 8. Melanthrips.
AA. Antennæ apparently five jointed, the last four segments being minute and compact
B. Body somewhat flattened; meso-metathorax broad; front wings without fringe on costal border, and with four distinct cross veins; males with lateral abdominal appendages.....Gen. 9 Coleothrips.
BB. Body cylindrical, mesothorax and metathorax constricted, wings rudimentary.....Gen. 10 Aeolothrips.

SYNOPSIS OF IOWA SPECIES.

GENUS PHLŒOTHRIPS, HAL.

A. Proximal joint of anterior tarsi armed with a tooth on inner side ..1
AA. Proximal joint of anterior tarsi unarmed.....2
1. With postocular bristle; three bristles on each side of prothorax; antennal joints 3-6 yellow.....*verbasci*, Osb.
Without postocular bristle; a single bristle at each posterior angle of prothorax; antennal joint 3 and base of joint 4, sometimes base of joint 5, yellowish.....*nigra*, Osb.
2. Black; head slightly longer than wide; tube three times as long as wide.....*caryæ*, Fitch.
Purplish-black; head one and one-half times as long as wide; tube twice as long as wide.....*mali*, Fitch.

Phlœothrips verbasci, Osb.

Description follows this paper.

Phlœothrips nigra, Osb.

Can. Ent., Vol. XV, p. 154 [1883].

Phlœothrips caryæ, Fitch.

[Third Report.] Trans. N. Y. State Agr. Soc. for 1856, Vol. XVI, p. 446.

Phlœothrips mali, Fitch.

[First Report.] Trans. N. Y. State Agr. Soc. for 1854, Vol. XIV, p. 806.

GENUS HELIOTHRIPS, HAL.

This genus is represented in the collections by a single species, *H. hæmorrhoidalis*, Bouché. It is probable that *H. dracœnæ* Heeger also, which occurs frequently in hothouses in this country and in Europe, is found in this state. These two species may be separated as follows:

Fuscous, apex of abdomen ferruginous; antennæ and feet pale; first and second joints of the former fuscous, sixth joint black---------- ---------- ---------- *hæmorrhoidalis*, Bouché.

Yellowish-brown; wings white, sub-fasciate with brown--*dracœnæ*, Heeger.

Heliothrips hæmorrhoidalis, Bouché.

Naturgeschichte der schädlichen und nützlichen Garten-Insekten, p. 42 [1833].

Heliothrips dracœnæ, Bouché.

Sitzungsb. d. mathem—naturw. Klasse d. Wissensch., Vol. XIV, p. 365 [1854].

GENUS SERICOTHRIPS.

One species, *Sericothrips? perplexa*, containing representatives of the male sex only, has been doubtfully referred to this genus. This species possesses well marked characters, evidently of generic importance, which do not accord with those of any genus of this family with which I am familiar. They are as follows: Head somewhat flattened or depressed and produced in front with the ocelli placed very far forward; fourth antennal joint decidedly longer than the third, apex of abdomen in male formed like that of females of this family. In Burmeister's Handbook of Entomology, Vol. 2, p. 413, the genus Sericothrips is characterized as having the abdomen covered with silky hairs, head hidden up to the eyes in the thoracic segment and the tip of the abdomen formed alike in both sexes. In the enumeration of species, the same authority records but a single species, hence it may prove that a more extended knowledge of allied forms will make it necessary to enlarge the limits of the genus, therefore it seems best to place this species here provisionally rather than to erect a new genus.

Sericothrips? perplexa, n. sp.

Male: Length, 1.33–1.55 mm. General color fuscous; legs and annulus on antennæ yellowish; thorax tinged with yellow-ferruginous; abdomen

except apex, varying from pale to deep fuscous; anterior wings subfuliginous, clearer at base. Form slender; bristles and spines short, inconspicuous; head, from dorsal view, subpentagonal; antennæ seven-jointed, approximate; ocelli placed very far forward toward front border of head; posterior angles of prothorax bisetose; spines on cubitus 15–16, arranged in a basal series of three or four followed by an intermediate group of nine, and this by two, more widely separated, at distal end of vein.

Head, seen from above, subpentagonal, its greatest length equal to its greatest width; sides constricted behind eyes; front margin produced, and subangulated in middle, its width almost completely occupied by the antennæ; eyes dark red-brown, of medium size, moderately granulated, pile scattered, long; posterior orbits depressed. with a row of short sparse hairs parallel to them; vertex scarcely elevated, gradually descending toward apex where it merges into the front; ocelli yellow, inner margins red; anterior ocellus on upper margin of front; lateral ocelli contiguous to upper orbits; ocellar bristles moderately long; small bristles between anterior ocellus and the eyes; occiput striate, provided with two weak bristles; front produced to base of antennæ thence receding toward clypeus, furnished with a row of four weak bristles just beneath antennæ and two similar bristles near clypeal margin. Antennæ seven-jointed, approximate, base plainly visible from above; joint 1 shortest and thickest, one-half the length of the second; joints 2–4 increase in length in the order named; joint 4 is nearly as long as joint 6, which is larger than any other joint; joint 5 is slightly longer than the second and more slender than any of the preceding; joints 6 and 7 are closely united and together pyriform in shape; the latter is nearly one-half the length of the former; the first joint is subrotund; the second, somewhat barrel-shaped; the third subfusiform; the fourth and the sixth elongate-ovate; the fifth submoniliform; the seventh lanceolate, its base narrower than the apex of the sixth; bristles and sensorial spines of joint 4 placed nearer the middle than usual.

Prothorax subquadrate, scarcely broader than head; sides very slightly constricted at anterior border; posterior angles narrowly truncate, provided with two bristles; shorter bristles or hairs are scattered over a triangular area extending backward from the front margin, and a smaller area near the posterior angles; anterior angles provided with equally small, but heavier bristles; surface apparently smooth; mesoscutum broadly convex, nearly smooth, furnished with short inconspicuous bristles each side and two submedian bristles on disc. The scutellum, obtusely ridged, feebly sculptured, provided with two short, heavy, approximate bristles on ridge near basal margin.

Abdomen slender; apex abruptly conical, resembling that of females of this family; sides distinctly sculptured; segments with a few bristles or coarse hairs laterally and on apical border of their ventral surface; caudal segments with longer and stronger radiating bristles arranged in two rings as in females.

Legs slender; anterior femora scarcely expanded; posterior tibiæ spiny on inner margin and at apex; their tarsal joints with apical spines. Anterior wings lanceolate, humeral angle moderately arched; cubitus extending entire length of wing; radial vein obsolete at base and nearly obsolete at tip; costal spines, 22–24; cubital spines, 15–16, arranged in

groups, three or four at base, followed by a group of nine, and this by two more widely separated, placed at distal end; radial spines, 13; anal spines, 5; longitudinal vein of posterior wing distinct.

General color fuscous; third and fourth joints of antennæ entirely and sometimes base of fifth, legs, except more or less of dorsal surface, yellowish: thorax, especially the sutures, tinged with yellow-ferruginous; abdomen varying from fuscous to yellowish or pale fuscous; apex always dark; dorsal aspect of femora generally concolorous with head; anterior wings subfuliginous with a broad, indistinctly defined, pale sub-basal band; posterior wings subhyaline.

Described from eleven specimens taken at Ames, Iowa, on *Cyperus*, corn and in sweeping grass in August and November.

GENUS CHIROTHRIPS, HAL.

This genus is represented by a single species, *Chirothrips antennata*, Osb., which is of a brownish-black color with third joint of antennæ paler; second joint is quite characteristic, being trapezoidal with acute angle outward.

Chirothrips antennata. Osb.
Can. Ent. Vol., XV, p. 154. [1883.]

GENUS THRIPS.

A. Head of medium size; eyes moderately prominent; antennal joints 3-5 elongate 1

AA. Head small; eyes very prominent; antennal joints 3-5 not elongate 8

1. Antennæ eight-jointed 2
   Antennæ seven-jointed 7
2. Sixth joint of antennæ annulated 3
   Sixth joint of antennæ not annulated 6
3. Ocelli widely separated; long bristles at all angles of prothorax; spines present at apex of all tibiæ, numerous and heavy on wings, on radial vein 12-14 4
   Ocelli subapproximate; single bristle of medium length at each posterior angle of prothorax, none at anterior angles; spines present at apex of posterior tibiæ only, on radial vein 2 5
4. Size medium; head, from dorsal view, rectangular; antennæ approximate ..... (*Euthrips*) *tritici* Fitch.
   Size large; head from above pentagonal; antennæ subapproximate ..... (*Euthrips*) *maidis* n. sp.
5. Wings more or less distinctly clouded; brown markings on thorax and band at base of abdominal segments 2-7 distinct ..... *variabilis*, n. sp.
   Wings nearly uniformly fuliginous; brown markings distinct on thorax; abdomen immaculate ..... var *a*.
   Wings and body, pale; markings, obsolete ..... var. *b*.
   Wings distinctly trifasciate; broad brown band on head

and thorax respectively; abdominal segments 1-3 and 7-10 entirely brown ..... var. *c*

6. Head, from dorsal view, semiovate; ocelli subapproximate, conspicuous; spines and bristles, short and few; bristles on penultimate segment of abdomen equally long ..... *striata*, Osb.
   Head, from dorsal view, subrectangular; ocelli remote, inconspicuous; single strong bristle at each posterior angle of prothorax; intermediate bristles on penultimate segment of abdomen, one-half as long as lateral bristles, *inæqualis*, n. sp.
7. Size medium; antennæ sub-approximate; ocelli inconspicuous; prothorax, transverse; bristles at posterior angles of medium length; spines at base of cubitus arranged in two groups ..... *tabaci*, Lind.
   Size large; antennæ approximate; ocelli, conspicuous; prothorax, subquadrate; bristles at posterior angles of prothorax, long; spines at base of cubitus in single group .. *lactucæ* n. sp.
8. Antennæ eight-jointed; ocelli approximate; spines and bristles, except those on abdomen, long and slender; bristle at middle of each lateral margin of prothorax, one at each anterior and two at each posterior angle ..... *pallida*, n. sp.

Thrips (*Euthrips*) *tritici*, Fitch.

[Second report.] Trans. N. Y. State Agr. Soc. for 1855, p. 536; Osborn Can. Ent., Vol. XV, p. 156 (1883).

Thrips (Euthrips) maidis n. sp.

Female. Length, 1.83-2.mm. A large species slightly variable in color, brownish-black, but sometimes paler; annulus on antennæ, extremities of femora and tibiæ, lower surface of the latter and sutures of abdomen yellowish-white; thorax, especially its sutures, tinged with yellowish-ferruginous; anterior wings dusky white; head pentagonal, front margin produced and rounded in the middle; ocelli distant, antennæ subapproximate; spines and bristles strong, blackish, arranged much as in *E. tritici*, Fitch; costal spines 25-29; cubital, 19-23; radial, 15-16; anal, 5; internal, 1.

Head, from dorsal view, pentagonal, scarcely broader than long; its sides parallel; anterior border produced and rounded in the middle; occiput less than one-half the length of the head measured on a median line, plainly striated; genæ uniformly full; eyes rather large, coarsely granulated, feebly pilose; orbits yellow, encircled with a few short hairs; ocelli, pale yellow, margined with red crescents, widely separated and arranged in a broad triangle with its lateral angles contiguous to superior orbits; vertex broad, gently convex between lateral margins; produced cephalad and provided with a transverse row of four short hairs near its anterior margin; the front wide with medial, longitudinal elevation; antennal sockets occupying less than its entire width, making antennæ subapproximate, more widely separated than in *E. tritici*, Fitch; antennal joints 3 and 4, occasionally base of 5, white, the rest, black; joint 1 globose, more than one-half as long as joint 2; the latter subglobose, somewhat contracted toward base, both joints more robust than those following: joints 3-5 elongate, submoniliform, decreasing in size in the

order named; the third nearly as long as the sixth; apical joints subequal, minute; all joints thinly covered with microscopic hairs; bristles or stiff hairs on basal and intermediate joints which on distal joints are replaced by slender hairs; sensorial spines on the third, fourth and sixth joints, distinct; clypeal, subantennal and postocular bristles present, the last less conspicuous than in *tritici;* mouth parts distinctly asymmetrical; each joint of maxillary palpi cylindrical, narrower than the preceding; first and third subequal in length, and second shorter than either.

Prothorax about one and one-half times as broad and equally as long as preceding segment; anterior angles rectangular, posterior rounded, sides slightly converging cephalad; disc striate and sparsely hairy; front and hind borders more deeply striate or rugose, bristly; the most conspicuous bristles are arranged as follows: One long bristle at each anterior and two at each posterior angle; two shorter bristles on anterior margin, two on posterior margin and one on disc near each posterior angle.

Meso-metathorax, subquadrate; mesoscutum more finely striate than prothorax, with small bristles, one at each lateral angle, two near and two on posterior margin; scutellum as long as mesoscutum, narrow, not strongly carinate; base transversely striate, sides longitudinally rugose; basal bristles as in *tritici.*

Abdomen broad, ovate, basal segments and sides sculptured, bristles similar to those of *tritici.*

Legs, with numerous short bristles; all tibiæ and joints of posterior tarsi with terminal spines; anterior femora incrassate, their tibiæ stout.

Wings rather broad; humeral arch not prominent; surface minutely pilose; veins distinct, uniformly and heavily spinose; anterior and posterior basal cross veins present; cubitus inserted in marginal at tip of wing; radius obsolete at proximal end, but perceptible before it unites with the posterior basal cross vein; costal spines longer than those on the other veins, numbering from twenty-five to twenty-nine; cubital, from nineteen to twenty-three; radial, from fifteen to sixteen; anal, five, gradually increasing in size from one to five; internal, one; posterior wings hyaline; longitudinal vein indistinct, except at base.

This form approaches closely the dark colored specimens of *tritici,* from which it may be separated by its larger size, the annulus on the antennæ, and especially by the shape of the head, which is pentagonal instead of rectangular, and the less approximate antennæ.

Described from twenty-nine specimens taken at Ames, Iowa, in July, August, September and January.

Thrips variabilis n. sp.

Head transverse Antennæ eight-jointed, distant; ocelli approximate. Each posterior angle of prothorax provided with a single medium sized bristle; bristles on penultimate segment of abdomen not strongly radiating, not extending backward beyond the base of the succeeding row; radial vein bispinose, obsolete; legs slender.

Female. Length from .84–1.23 mm. Head one-half as long as broad; viewed from above, subrectangular; anterior margin straight; occiput short, transversely convex and striate; distinct oblique depression behind each eye; genæ moderately full; vertex abruptly ascending, tumid

across whole anterior border; ocellar area small, elevated; ocelli approximate, inner margins heavy, conspicuous: ocellar bristles not more than one-half the length of the head; eyes large, prominent, feebly pilose. Antennæ eight-jointed, distant, moderately bristly; basal joint short, thick, hidden from dorsal view by vertex; the following joint longer, more robust, globose; joints 3–6 elongate; joint 3 the longest, subfusiform; joint 4 a little shorter than joint 3, elongate-modioliform; joint 5 obovate, intermediate in length between 2 and 4; the remaining joints sessile, together elongate-conical; joint 6 equal to joint 4 but a little stouter; joints 7 and 8 minute, together one-half as long as preceding, line of separation between them oblique; sensorial spines on joint 6 originate beyond middle; four short bristles in transverse row on front above antennæ, and one behind each eye; mouth parts nearly symmetrical.

Prothorax broader than long; anterior angles prominent, rectangular; posterior angles broadly rounded and furnished with a single bristle; surface plainly and uniformly marked with transverse striæ, with a few short slender bristles on front margin and more on disc. Mesoscutum is quite convex from base to apex, marked with fine transverse striæ, and provided with four short bristles on disc. Scutellum with triangular area at base striate as in mesoscutum, furnished with four basal bristles.

Abdomen broad, ovate; sides, under high power, appear thickly set with minute appressed hairs; a pair of bristles occurs on disc of each segment from the second to the seventh; they are approximate on the second and gradually become more widely separated on the succeeding segments; lateral bristles few and short; apical border at sides and on ventral surface of segments bordered with minute ciliæ interspersed with coarse hairs or bristles; caudal spines rather light; those on penultimate segment directed backward and extending only to base of following segment; terminal spines a little longer than the preceding, radiating at sides.

Legs very slender, somewhat bristly; tarsi elongate; anterior femora not dilated; apex of intermediate and posterior tibiæ and of posterior tarsal joints terminating in short spines; inner margin of posterior tibiæ feebly spinose.

Wings; veins heavy; in anterior pair radius and cross veins obsolete; costal spines number 22-30; cubital, 20-26, arranged in two series; radial, 2; anal, 4; one near base of anal cell; longitudinal vein of posterior wing very heavy for two-thirds of the length.

Male. Length, 78-86 mm. Resembles the female very closely. Differs in being of smaller size, in having from 23-25 costal spines, 20-21 cubital: the remaining spines on the wing as in female. The apex of the abdomen is more blunt; the anal segment is cleft on either side, the lateral lobes terminate in two spines; the middle lobe is prolonged considerably beyond the lateral lobes, making apex more pointed than apex of male of *T. tritici*. The spines on preanal segment are similar to those in female.

This species presents considerable variation in color. The extreme forms are quite distinct and might almost be considered separate species were it not that in addition to the similarity in structure there is the occurrence of a series of intergradient forms.

Var. *a.* Female: General color yellowish-white, meso-metathorax pale yellow, basal joints of antennæ concolorous with head, joint 3 and base of joint 4 dusky; the remainder of the antennæ and spot at distal end of tarsi, brownish-black; eyes dark red-brown; ocelli nearly colorless; inner margins red; anterior wings indistinctly clouded with fuliginous at base, distal portion clearer; brown markings as follows: A clearly defined saddle-shaped patch on posterior portion of prothorax, concave along its front border, nearly interrupted by a wedge-shaped incision extending forward from posterior border; anterior border of mesonotum; scutellum except median stripe; bands at base of abdominal segments two to seven, dilated at sides, and narrower and fainter along intervening space; patch on upper side of all the femora, darkest on posterior pair.

One specimen, taken on clover August 14, 1893, and one on hackberry, October 6, 1893, Ames, Iowa.

Another specimen taken on hackberry, October 6, 1893, at Ames, Iowa, corresponds with the description of variety *a* except that the thorax is a deeper yellow.

Another specimen taken on elm, August 21, 1894, is more uniformly yellow, the anterior wings more uniformly dusky, bands at base of abdominal segments narrower and other markings fainter.

A fourth specimen that may be placed in this group resembles the first, but it is of a deeper yellow color; the markings on the prothorax are prolonged farther backward, and the wings are more uniformly fuliginous. Ames, Iowa, Oct. 8, 1893.

Var. *b.* Male and female: Body pale yellowish, immaculate; apical joints of antennæ black, remainder pale; wings and fringes tinged with yellowish.

Hawthorn and hackberry, Ames, Iowa, October 6, 1893.

Var. *c.* Male and female: Wings nearly uniformly fuliginous; last three joints antennæ, distal half of joints 4 and 5 black, sometimes intermediate joints altogether dusky; brown markings very distinct, confined to two large spots on thorax and scutellum respectively, the latter oblong and approximating posteriorly; abdomen immaculate.

Hawthorn and hackberry, October 6, 1893, Ames, Iowa.

Var. *d.* Male and female: This variety is characterized by having the wings fuliginous, trifasciate with white bands, and in being more heavily marked with brown; the markings on the thorax and bands at base of first, second and third (sometimes of second and third only), and seventh and eighth segments of the abdomen are extended until they coalesce and form broad bands; the dorsal surface of the head is brown; sometimes all of the caudal segments are brown; the legs are white, with brown streaks on dorsal surface of femora, and frequently on tibiæ also; antennæ as in preceding variety.

On smartweed, June 16, 1893, and on cucumber, July 28, 1893, Ames, Iowa.

By the shape of the head and by the antennal characters this species is allied to *T. tritici*, but it may readily be distinguished from it by the smaller and more approximate ocelli, the absence of large conspicuous bristles on the thorax, the difference in the number of spines on the wing, and the more slender legs.

Thrips (*Euthrips*) *striata*, Osb.
Can. Ent., Vol. XV, p. 155.

Thrips inequalis, n. sp.

Female: Length, 88 mm.; yellow; style and distal portion of antennal joints, 3-6, black; joint 6 distinctly annulated toward apex; posterior angles of prothorax with a single bristle; lateral bristles on dorsum of penultimate segment of abdomen twice as long as intermediate pair.

Head, broader than long, contracted at posterior border, occiput forming not more than one-half of its dorsal surface; genæ uniformly full; eyes of medium size, moderately prominent, distinctly pilose; vertex uniformly tumid at anterior margin, becoming transversely convex and descending toward posterior margin; ocelli subapproximate; front, above insertion of antennæ, longitudinally elevated along median line.

Antennæ subapproximate; the two basal joints stout, subequal; the second barrel-shaped, more than one-half as long as succeeding; joints 3-6 subequal in length and less elongate than in *T. tritici;* joints 3 and 4, thick, irregularly turbinate, gibbous below insertion of sensorial spines; joint 5, smaller and more regular in shape; the remaining joints form an elongate oval; joint 6 has a distinct articulation on distal half, similar to the annulation on the sixth antennal joint of *T. striata*, Osb.; this may be an indistinct annulation, in which case the antennæ would be properly considered nine-jointed, three of the joints forming the style; the ultimate joint is nearly cylindrical and longer than the penultimate, which is of the same length as that portion of the joint 6 between the annulation and the apex; the joints are furnished with a few medium-sized bristles or stiff hairs, which become finer toward the distal end of the antennæ; sensorial spines as in *T. tritici.*

The prothorax is one and one-half times as long as the head, equally as broad at anterior border and about one-third broader at posterior border. The disc is convex, rather indistinctly striate and sparsely set with stiff, blackish hairs or bristles, which are almost entirely wanting on median portion, and most numerous near lateral and posterior borders. Posterior angles with a single long bristle.

The disc of the mesoscutum is convex, finely striate, elevated at posterior border, provided with a single short bristle near each lateral angle, two on disc and two on posterior margin. The scutellum is trapezoidal, gently sloping from the very small elevated area near base toward posterior and lateral margins; on the basal margin are two widely separated and two short approximate bristles.

The abdomen is ovate, resembling that of *T. tritici*, Fitch, in an arrangement of bristles, except that the median pair on penultimate segment is but one-half as long as those on either side.

Legs, especially femora and tibiæ, thinly covered with short, coarse hairs which are replaced by bristles at apex of anterior and intermediate tarsal joints; inner margin of posterior tibiæ feebly spinose; its apex and apex of its tarsal joints terminating in spines; anterior femora moderately dilated.

Anterior wings nearly attain tip of abdomen: veins heavy; inner marginal vein very distinct; costal fringe rather heavy; costal vein bears from 24-28 spines; radius, 18-19, those on basal half of vein separated into two groups of four each, the intervals between the rest growing wider toward the distal end of the vein; cubitus, 10–11; anal, 5; anal cell, 1.

Color yellow, deeply tinged with orange on thorax and abdomen, faintly dusky along median line of thorax and abdomen; head and two basal joints of antennæ, whitish; proximal portion of joints 3-6, dusky; remainder of antennæ and spot near apex of tarsi, black; eyes, red-brown; ocelli, pale yellow; inner margins, orange-red; spines and bristles blackish; anterior wings and fringes tinged with dusky yellow.

Described from a single specimen taken with *T. tritici* on aster at Ames, Iowa, September 16, 1893.

Thrips tabaci, Lind.

Schädlichsten Insekten des Tabak in Bessar. Abien., pp. 62-63. (1888.)

Thrips lactucæ, n. sp.

Female: Length, 1.40 mm. General color pale yellow, with two broad diverging stripes on middle of thorax, a narrow band at base and one or more spots at sides of abdominal segments brown. Form elongate; anterior border of head convex. Antennæ seven-jointed, proximal joints pale, remaining joints black. Wings variable in size. Ocelli conspicuous, placed close together near posterior margin of vertex. Spines and bristles stout, on thorax, arranged much as in *T. tritici;* the cubital spines are grouped into two series, a basal group of seven, followed by three, more widely separated, on distal portion of vein.

Head scarcely broader than long; outline seen from above semiovate; occiput, feebly striate, one-half the length of the head, with shallow, longitudinal furrow each side behind the eye; genæ, broad, full, prolonged posteriorly; vertex elevated, convex between the eyes, ascending and expanding towards apex, front margin arcuate; ocelli conspicuous, remote from anterior border of vertex, inner margins heavy, contiguous in front; ocellar area elevated; ocellar bristles of medium size; eyes, moderate, pilose; a row of bristles on front, beneath insertion of antennæ, is partially visible from above; a few microscopic bristles around orbits; antennal sockets prominent, easily seen from above; antennæ approximate, seven-jointed; the intermediate joints elongate; joint 1 is one-half the length of joint 2, equal to or longer than joint 7, semiglobose; joints 2-5 are subequal in length; joint 2 is cupshaped, a little shorter but much stouter than any of the three immediately following; joints 3-5 are moniliform;

pedicel of 3 is short; joints 6 and 7 together form an elongate oval; the latter is acuminate at apex two-fifths the length of the former and terminates in two or three long slender hairs; surface of all the joints set with minute appressed hairs and furnished with a few bristles which are arranged in a preapical ring on joints 2-5, and on remaining segments are replaced by slender hairs; sensorial spines on joints 3, 4 and 6, distinct.

The prothorax is subquadrate, a little longer and wider than preceding segment; posterior angles nearly rectangular; posterior border margined; surface nearly smooth and, with the exception of two discal areas, covered with coarse, stiff hairs which are largest near lateral and posterior borders; two short bristles at each anterior angle and four longer ones near front border; two large, strong, subequal bristles at each posterior angle, two of moderate length on hind border, and a similar one on disc near each posterior angle.

The surface of the mesoscutum is apparently smooth, its posterior discal portion only moderately elevated, provided with two small bristles; two similar bristles occur on the posterior border, and one at each lateral angle. The metanotum is very short. The scutellum is obtusely carinated, its surface longitudinally striate, provided with two approximate submar ginal bristles on anterior portion of disc, and two, more widely separated, on basal margin.

Abdomen is quite uniform in width, convex above, striate at base and at sides; base slender; apex short, conical; segments constricted, bearing a few stiff hairs on dorsal and ventral surfaces and a few bristles at sides; both hairs and bristles become stronger on anal segments, where the latter are arranged in two rings.

Legs, especially posterior pair, slender; anterior femora but slightly expanded; hind tibiæ spiny on inner margin, terminating in three strong spines, joints of their tarsi also furnished with apical spines; entire surface bristly, especially at apex of intermediate and anterior tibiæ.

Wings varying in size from rudimentary to fully developed; the anterior pair slightly dusky, posterior pair hyaline; in fully developed wing the cilia on costal border of each pair is short and sparse, on posterior border longer but not very heavy; venation of anterior wings rather weak; anterior and posterior basal cross veins present, but not distinct; costal vein furnished with 18–21 spines; cubitus, 10; radius, 10–11; anal, 5; anal cell, 1; spines on cubitus are arranged in a basal group of seven, followed by three more widely separated on distal end of vein; longitudinal vein of posterior wings incrassate at base, not quite attaining tip of wing.

Color usually pale yellow, deeper on thorax and legs, the latter frequently dusky; head and proximal joints of antennæ white, intermediate joints brownish-black at base, the rest of the antennæ deep black; occiput often tinged with yellow, sometimes dusky; eyes dark red-drown; ocelli yellow, inner margins brick-red; prothorax at margins, disc of mesonotum, pleuræ, except upper portion of mesopleuræ in front, narrow medium stripe on scutellum, pale; two spots or patches on prothorax, sometimes diffuse and coalescing sometimes nearly or quite obsolete, two broad, approximate stripes on scutellum, diverging slightly and extending outward and backward in a broken and interrupted line to lateral margin, upper portion of mesopleuræ in front, brown; abdomen somewhat dusky, more or less pale

at sides and toward apex; narrow basal band on segments 2-7, expanding laterally and broken up into spots, one of which is more conspicuous than the others, brown.

Femora and tibiæ dusky or brownish on upper surface, pale on lower surface and at base, the latter also pale at tip; anterior wings dusky yellowish; spines brown.

By its seven-jointed antennæ. *T. lactucæ* is allied to *T. tabaci*, Lind., but it is more heavily marked with brown; the color of the intermediate joints of the antennæ is darker; the antennæ and the ocelli more approximate; the ocelli more conspicuous and farther removed from the anterior margin of the vertex; the prothoracic bristles larger and less uniformly distributed, being entirely absent from two discal areas; those at posterior angles, longer; proximal spines on cubitus arranged in a single group.

Described from numerous specimens taken on wild lettuce in October, November and March, at Ames, Iowa.

T. lactucæ bears some resemblance to *T. tritici* in size and general color, from which it may be easily separated by the fewer antennal joints, less rectangular head, less widely separated ocelli, absence of long bristles at anterior angles of prothorax, less numerous cubital spines and their arrangement in groups, absence of spines at apex of intermediate and anterior tibiæ and inner margin of posterior tibiæ.

From *T. striata* it may be known by the difference in number of antennal joints, absence of annulation on sixth joint, presence of longer and more numerous spines and bristles.

Thrips pallida n. sp.

Female: Length 1.12 mm. Color varying from white to pale yellow. Antennæ, beyond basal joints, more or less dusky. Head small, eyes large. Anterior wings partially trifasciate. Bristles on anterior portion of body long and slender. Prothorax characterized by the presence of a long bristle on the middle of each lateral margin in addition to those at anterior and posterior angles.

Head small, about as long as broad. Occiput very short, not more than one-third the length of the head. Eyes dark red-brown, very large and prominent, sparsely and feebly pilose. Vertex narrow, elevated, transversely convex, ascending toward the anterior margin, the latter arcuate. Ocelli in middle of vertex, nearly colorless, their inner margins white, contiguous anteriorly. Ocellar bristles as long as the head. Front prominent, bearing a row of recurved bristles above insertion of antennæ. Mouth parts short, nearly symmetrical.

Antennæ approximate; the two basal joints the stoutest; joint 1 semiglobose, one-half the length of joint 2; the latter is stouter than the former, barrel-shaped, equal in length to joint 5, and a little shorter than joints 3 or 4; these are robust, subequal in length and broadly obovate, the pedicel of joint 3 is short and slender; joint 5 is oval and less robust than the two immediately preceding; the remaining joints are sessile, together form

an elongate oval; joint 6 is longer than any other joint; joints 7 and 8 are short and of equal length, base of former narrower than apex of 6; apex of 8 is lanceolate. Bristles and hairs are of equal size, and arranged much as in *T. tritici.* The long sensorial spine on outer side of joint 6 originates below the middle of the joint.

The prothorax is convex; its sides converge cephalad; its surface is nearly smooth, with a double median transverse groove or double impressed line and a few short and several long slender bristles, the latter arranged as follows: one at each anterior angle, two on intervening space of anterior border, one at middle of each side, one near and two at each posterior angle. The mesoscutum is longitudinally convex, its surface nearly smooth, furnished with two lateral bristles directed inward, and two smaller ones on disc and on posterior border, respectively. The scutellum is subrectangular, obtusely carinated, descending toward the apex; on basal margin provided with two distinct bristles which extend nearly to apex.

The abdomen is slender at base, ovate, with few conspicuous bristles; those at apex of ultimate segment much shorter and weaker than those on preceding segment.

Legs are moderately stout, bristly; anterior femora incrassate, their tibiæ stout; spines present at apex of posterior tibial and tarsal joints, on inner margin of tibiæ replaced by bristles.

The anterior wings are whitish, slender, rather thin, subfasciate with three dusky spots; the first near base of anal area, the other two dividing the remainder of the wing into three subequal parts; sometimes a faint spot may be detected near apex of wing; these spots are variable in distinctness and may be obsolete; ciliæ of inner margin, light; of outer margin, sparse and scarcely longer than the spines with which they are interspersed. Radial vein is obsolete between base of wing and posterior basal cross vein, consequently it appears to originate in the cubitus. Both radius and cubitus terminate abruptly before attaining marginal vein. Cross veins connecting costal and cubital veins are obsolete. The costal vein bears from 15-20 spines; the cubital, 10; radial, 5; anal, 4, and posterior marginal vein 1, placed opposite the posterior basal cross vein. The posterior wings are hyaline; proximal end of longitudinal vein incrassate.

Male. Length .97 mm. Smaller than the female, but very similar in distinctive characters. Apex of abdomen is bluntly conical, less truncate than in male of *T. tritici,* partially trilobate, the lateral lobes are very narrow, shorter than the middle lobe, and terminate in a single long bristle. Penultimate segment terminates in a row of short sparse bristles, on dorsum, and single long spine on each side.

Described from ten females and seven males. Taken on bean and elm at Ames, Iowa; on blackberry at Belle Plaine, Iowa, and on hop at Barraboo, Wis.

Thrips pallida is a well marked species and is readily separated from the other species included in this paper by the small head, the presence of a bristle on middle of lateral margin of prothorax, the feeble armature of inner margin of posterior tibiæ and the number of spines on the front wings.

NOTE ON A NEW SPECIES OF PHLŒOTHRIPS, WITH DESCRIPTION.

HERBERT OSBORN.

In connection with the paper by Miss Beach on the Thripidæ it seems desirable to describe a species which has for a long time been in our collections, but has not received a technical description.

Phlœothrips verbasci, n. sp. Black, polished; head quadrate with a prominent post-ocular bristle; prothorax widened behind; first joint of anterior tarsi armed on inner side with a curved tooth.

Female: Head quadrate, very slightly constricted behind, a prominent bristle behind the eye; antennæ light yellowish with dusky base and tip, joints 1 and 2 black, 3–6 yellow, 7–8 dusky, ending with two bristles; prothorax widening behind, with prominent angles, three lateral bristles; meso and meta-thorax subquadrate. Legs black except anterior tibiæ and all tarsi which are yellow, the tarsi somewhat clouded with dusky. Anterior tarsi with a short curved tooth on inner side of first joint at middle. Wings hyaline except base of anterior pair, which is fuliginous; anterior pair with no fringe at base; anal vein entire; median vein distinct at base, but becoming obsolete; three long spines in a row on the inner side of the median vein near base; posterior wings at base with two long, slender bristles near together on hind margin; abdomen at apex with six long and seven short bristles; tube reticulate.

Male smaller than female and having two slender spines on a slight elevation at side of the anterior margin of the first segment of the abdomen.

Length of male 1.50–1.60 mm., female 1.80–1.90 mm.

This species stands near to *nigra*, Osb., but differs decidedly from that species in the more quadrate head, prominent posterior angles of the prothorax, as also in the presence of two prominent bristles just behind the eyes and the different number and character of bristles at apex of tube.

It occurs almost invariably in mullein, hibernating in the stools, and may be found in early spring at the base of the fresh leaves, especially among the dense interior leaves. The whitish, cylindrical eggs are deposited during April, and larvæ develop on the mullein leaves. The larvæ differ decidedly from the larvæ of *nigra*, in being yellow or orange instead of deep red.

Adults, bred forms of which matured June 20th to 26th, are found in mullein blossoms in midsummer (July), and probably produce a second brood. Adults have been taken in September in the seed pods, and in November at the base of dead mullein stalks.

This is the species referred to in my article on "The Food Habits of the Thripidæ" (Insect Life, Vol. I, p. 141) as *Phlœothrips sp.*, the species being cited in evidence of an herbivorous diet for the *Thripidæ*.

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